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INTERNATIONAL RAILWAY CONGRESS

ASSOCIATION

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NINTH SESSION

ROME : APRIL 1922

GENERAL PROCEEDINGS

1st Section : WAY AND WORKS

INAUGURAL MEETING

19 April 1922, at 9.0 a. m.

Provisional president, Mr. MAURIS,
member of the Permanent Commission of the Association.

The President. (In French.) — Gentlemen. The Permanent Commission of the International Association has requested me to proceed with the inauguration of the first section, and also with the constitution of the secretariat for the same. It will be your duty, as I am sure it will be your pleasure, to nominate a president, two vice-presidents, a principal secretary and six other secretaries.

For the presidency I have the honour to propose to you Mr. Bruneel, administrator-president of the Belgian State Railways and member of the Permanent Commission. (*Applause.*)

I have no need to praise Mr. Bruneel to you because he has for so long a time carried on with distinction the duties of chief engineer of Way and Works on the Belgian State Railways, and during his long career his term of office has been distinguished by remarkable achievements marked by great technical and administrative ability. In fact these are the reasons why, when Mr. Tondelier relinquished his duties as president of the Belgian State Railways, Mr. Bruneel was called upon to succeed him.

You know quite well that the idea of connecting the two important terminal

stations, the Nord and the Midi, of the city of Brussels, was due to him; a great work which would in all probability have been finished by this time if the events of 1914 had not prevented the continuation of the work which had already begun. This, however, in consequence of the financial position of the State, has not resumed up to the present. I hope that this great work, which will be of immense service to the community and will do honour to he who has conceived and prepared it, may soon be brought to fruition.

In calling upon Mr. Bruneel to preside over the work of the first section you will be making an excellent choice. (*Loud and long applause.*)

I propose further to nominate as vice-presidents Mr. Barrand, general inspector of Road and Bridges; director of control of Way and Works at the Ministry of Public Works of France, and Mr. Deyl, engineer, superior councillor of the State Railway of Czecho-Slovakia. The reputation of these two candidates is sufficient to recommend their nomination to your favour. You all know Mr. Barrand who is distinguished for the remarkable works in which he has demonstrated his great technical ability. He has supervised with undoubted authority the control of railways at the Ministry of Public Works of France, and in these delicate duties he has shown that he possessed the force of character, and spirit of justice, which has earned the greatest esteem of the railway administrations. As for Mr. Deyl, I will only say that his reputation is such that it will completely justify your choice.

— These two nominations were received and confirmed with the unanimous and prolonged applause of the assembly.

The President. (In French.) — I now propose to you the nomination as chief secretary of Mr. G. Tronconi, engineer, chief inspector of Works of the Italian State Railways. (*Applause.*)

— The section, on the proposition of the President, then appointed the remainder of the secretarial staff.

The President. (In French.) — Gentlemen. Your staff is now complete, and I have now to wish that you may achieve to fruitful results the study of the important questions so carefully reported which will be submitted to you. (*Applause.*)

— The meeting rose at 9.45 a.m.

Meeting held on 19 April 1922 (morning).

Mr. BRUNEEL, IN THE CHAIR.

— The meeting opened at 10 o'clock.

The President. (In French.) — Gentlemen, my first word must be one of thanks and gratitude for the very great honour the 1st section has paid my country in calling upon me to preside over its deliberations. I thank you also personally for the honour, and I feel very deeply the way in which you received the kind words, too kind in fact, in which Mr. Mauris referred, in terms which touched me very much, to the work which I have carried out, and especially that in connection with the Nord-Midi Junction at Brussels which I have for twenty-five years been engaged upon. No one could appreciate more highly than I do the high honour and the important work you have confided to me.

I have in fact the privilege — the sad privilege which comes with age — of being one of the oldest members of the Congress. I am one of the very few — there are only two or three of us left I am afraid — who took part in the first proceedings in 1885, that is to say thirty-seven years ago, which started these meetings. I know quite well how important our discussions have been, and what happy results have followed from the work we have all helped to carry out.

With Mr. Mauris, I believe that the work of this section will be fruitful in its results.

Before we settle down today to our work, I wish to render homage to the country in which we are met, — Noble Italy, — so great in the past and, in the recent tragic hours we have passed through, still further raised in the esteem and admiration of the world.

We bow solemnly before her. (*Applause.*)

I also salute our dear Italian colleagues, so given to hospitality; we feel deeply touched by the hospitality shown us, so cordial, so sincere and so full of attention. I would I were able at this time to express myself in their beautiful language, so musical and so full of harmony. It is a language which enchants our ears, as their wonderful country does our eyes.

We wish to offer them here and now the cordial assurance of our friendship, and we appreciate very fully the hospitality which they offer us, and above all the hearty welcome with which we have been received. (*Applause.*)

And now, Gentlemen, to business, for the work before us is long and arduous; the reports we have all received show the importance of what we have to do. I feel I am correct when I say that some of the reports are valuable treatises on the subjects they deal with. We must then put our best efforts into this work, and I hope — for this will be the crowning achievement of my connection with the Congress — that the results of this session will be no less valuable than those of previous Congresses.

I know that I shall have the help and assistance of you all, and I do not doubt that the most satisfactory results will crown our efforts. (*Applause.*)

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QUESTION I

CONSTRUCTION OF THE ROAD BED AND OF THE TRACK.

Arrangements to be adopted in constructing the road bed and the track, in view of the increase in the weight of locomotives and the speed of trains.

Preliminary documents.

1st report (America), by Mr. H. U. Mudge. (See English edition of the *Bulletin* of August 1914, p. 713, or separate issue [with red cover] No. 2.)

2nd report (all countries, except Denmark, Sweden, Norway, Great-Britain and America), by Messrs. Henry and Candelier. (See English edition of the *Bulletin* of October 1920, p. 639, or separate issue [with red cover] No. 8.)

Supplement to 2nd report, by Messrs. Henry and Candelier. (See English edition of the *Bulletin* of January 1922, p. 251, or separate issue [with red cover] No. 56.)

3rd report (America), by Mr. C. H. Ewing. (See English edition of the *Bulletin* of July 1921, p. 835, or separate issue [with red cover] No. 20.)

4th report (Denmark, Sweden and Norway), by Mr. K. Ahlberg. (See English edition of the *Bulletin* of September 1921, p. 1147, or separate issue [with red cover] No. 28.)

5th report (Great-Britain), by Mr. E. F. C. Trench. (See English edition of the *Bulletin* of August 1921, p. 991, or separate issue [with red cover] No. 24.)

Special reporter : Mr. Henry. (See English edition of the *Bulletin* of April 1922, p. 623.)

SECTIONAL DISCUSSION

The President. (In French.) — I call upon Mr. Henry, special reporter, who has undertaken to summarise and co-ordinate the different reports which have been made on this question.

Mr. Henry (In French) read the special report which he had drawn up and which has been published in Number 4, April 1922, of the *Bulletin*.

The President. (In French.) — In accordance with the regulations, I have to ask the other reporters if they wish to add any remarks to the summary drawn up by Mr. Henry.

Mr. Ahlberg, *reporter*. (In French.) — As far as I am concerned I have nothing to add to the summary we have heard which is perfectly correct.

The President. (In French.) — I think, Gentlemen, we ought to divide the discussion, dealing first with the *strengthening of the formation*, that is to say, top and body of the embankments and the bottom and slope of the cuttings. Following this the discussion should be on *strengthening of the track*, by which we mean the cushion which should distribute the pressure put on the rails to the top of the embankments or bottom of the cuttings.

Several reports have raised the question of the preliminary preparation of the ground on which the embankment is to be built, of the condition which should be complied with and the materials which should be used.

I will ask Mr. Ahlberg if the translation of his report into French adequately expresses his ideas in the following extract :

With the same object a row of iron tubes is inserted in a sloping direction in the lower edge of the bank. Charges of dynamite are then placed in the tubes and exploded. When, as a result of this procedure, the embankment has settled evenly, further material is added, after which the same procedure is repeated until it is quite certain that the banking material has reached the solid foundation.

I ought to say that in reading this translation I have not entirely grasped Mr. Alhberg's meaning. Will he kindly give us some explanation of the object he had in view and of the results he obtained?

Mr. Ahlberg. — The method to which I allude has been employed on different occasions in Sweden, when the sub-soil is composed of very soft clayey soil. By this method one manages to bring about the descent of the embankment and to reach the firm soil.

The President. (In French.) — This will allow of the bed of clay being separated so as to permit the earth of the embankment penetrating through to good soil.

Mr. Henry, *special reporter.* (In French.) — Is it not rather to obtain a compressive effect on the subsoil?

Mr. Ahlberg. (In French.) — It is to obtain a stronger foundation for the embankment.

Mr. Deyl, *vice-president.* (In French.) — The administration of the State Railways of Czecho-Slovakia has not previously had the opportunity of taking part in this discussion, this administration only having belonged to the Association since 1921.

I have prepared a report dealing with the formation and track of the lines of the State Railway of Czecho-Slovakia. I have the honour of handing this report to the Principal Secretary of the section.

The President. (In French.) — The report of Mr. Deyl will be published in the *Bulletin* as an appendix to the discussion on question I. (See appendix 2.)

I trust that my colleagues will agree to start with the discussion relating to the consolidation of the formation of the road.

The Eastern Railway Company of France has recently carried out some interesting work in this direction; we shall listen with great interest to Mr. Henry if he will give us the results of the work carried out on this subject.

Mr. Henry. (In French.) — We have used intercepting drains on certain lines of the Eastern Railway since 1860; they are run parallel to the track and 82 feet behind the cutting. These drains were generally placed at a considerable depth

which rendered inspection practically impossible; one is only able to examine their outlet periodically to see if water is flowing from them.

After a certain number of years considerable slips of the slopes occurred in certain cuttings which resulted from the blocking of these drains. These obstructions resulted in the formation of water pockets which finally found an outlet in the slopes of the cuttings.

We have therefore had to abandon the use of these intercepting drains which can only be recommended if they are capable of efficient inspection; in order that this may be done properly it is necessary to put in a drain of large size — a culvert in fact. This is an expensive matter, and such expense is not often justifiable.

The President. (In French.) — I have, as Mr. Henry finds it desirable, put in, in certain difficult cuttings, permanent drains which consist of masonry culverts with perforated sides surrounded with dry lining. I wish, however, to say a word or two in favour of the use, in certain special cases, of intercepting drains which are not large enough to allow of complete inspection.

We have had to make use of them, since the war, in the neighbourhood of Ypres where, as you know, the ground has been broken up to a considerable depth by the explosion of shells and mines. We find there an earth which we call in geological terms the Ypresian earth, which is composed of very fine glauconite sand lying on and alternating with beds of clay. This soil, ploughed up by shell fire, was made into a series of basins which formed reservoirs for the water. This water penetrated the sand until it reached a bed of clay lying at an angle, here it ran along the surface of the clay and caused the earth above it to slip.

We had to reinstal a line which crossed this soil in a deep cutting; the old road was so completely destroyed at this point that the engineers could only, with difficulty, trace where it had been.

We started by placing an intercepting drain above and at some distance from the point at which we wished to excavate the cutting. This drain, which was only a means to allow us to carry out our work, was built of dry stone. We were of necessity put to considerable expense, but it was necessary at all costs to push on with the work. Thanks to this method of making a temporary drain filled with dry rubble, we were able to carry out work of a very delicate nature. It will be seen that we adopted a serviceable method of draining the soil, although it may only have been efficacious for a time, but more was not necessary, as in the permanent replacement of the line it will be moved so as to do away with the deep cutting and the stiff gradients which lead up to it.

As we are considering special cases, I would like to quote another expedient I adopted myself twenty years ago in a cutting where I found that at certain points the surface was so soft that it would not admit of a man walking across it.

I had in this case to make borings and drain vertically. The borings showed me that under the soft layer was a large bed of clay which at certain places allowed water to accumulate. My borings showed that under the bed of clay was dry sand, and I therefore drove vertical boreholes through the clay into the permeable sand underneath and allowed the water collected over the clay to drain through into this.

The result was satisfactory at once.

It will be very interesting if each of you will give us the benefit of any such experiences you may have had.

Mr. Barrand, *vice-president.* (In French.) — I agree in this matter with Mr. Henry.

In my capacity as a member of the General Council of Bridges and Roads of France, I have knowledge of a number of accidents which have occurred on various lines owing to the use of intercepting drains, and I know of proposals put forward with a view to remedying such slips. Several of these proposals are already in hand.

We have known of drains which have functioned properly for a certain period, but have become blocked, because when built they have not been arranged so that they can be inspected regularly and completely.

In reality, the General Council of Bridges and Roads of France forbid the use of intercepting drains, except under exceptional circumstances — the principal exception is — when it is necessary to get rid of water as rapidly as possible. In every case when it is necessary that intercepting drains should be agreed to, we insist that they shall be built in such a way that they can be easily inspected.

M. Jullien, Paris-Orleans Railway. (In French.) — I desire to emphasise how necessary it is in constructing a railway to bear in mind the heaviest loads which will be allowed to run on the line when arranging for the road bed. I say this because when earth once starts moving it is a very difficult matter to stop it. It is easier to prevent the evil than to cure it. I trust that my colleagues of the 1st section will communicate to us the methods which they employ for the making sound, and maintening in a safe state of equilibrium, clay cuttings, and that they will say whether the methods employed have given really effective results.

The President. (In French.) — As there are no other speakers on the subject of the strengthening of the formation of the road, we ought now to deal with the question of the road bed and ballast.

Mr. Henry mentioned the great importance which he attached to placing under the ballast a bed of material which would allow the water to filter away, but which is of such a nature as to prevent the subsoil from working up into the ballast.

Mr. Pinto Guzman, Ministry of Public Works, Ecuador. (In Italian.) — I wish to mention the enormous difficulties that we meet with in South America. I wish to call special attention to the country in the North of Ecuador and in Peru. I would call particular attention to Ecuador, where our chief problem is due to the fact that the line rises to 11 500 feet from sea level. There the ground is full of water, and it is necessary to build large embankments of gravel or of broken stone; as the line rises, hard rock and bad ground of volcanic origin are met with, particularly at a height of 8 200 feet. The chief difficulty consists in laying the track on the side of the mountain.

The different projects which have been put forward for preventing the slip of earth works did not help, because it is the entire mountain which moves down with the railway.

We have, however, given great care to the line in spite of the very considerable difficulties which we encounter owing to the nature of the soil. Numerous experiments carried out with a view of finding a suitable solution have not solved the problem. A line has been laid, but it is found that the mountain moves down and the road has had to be put right every three months; this of course is not a definite solution of the problem.

The President. (In French.) — Would you be good enough to tell us the na-

ture of the soil? Is it wholly volcanic?

Mr. Pinto Guzman. (In French.) — It is schifting earth.

The President. (In French.) — Has it not been possible to find the bed of the slip?

Mr. Pinto Guzman. (In French.) — It is a general slipping of the mountain. We have not been able to find the actual surface on which the slipping takes place, although we have tried. Volcanic sand is found to a great depth. The track has been filled in where it has sunk, and rectified where it has been raised. Although a retaining wall has been placed at the foot of the mountain, it continues to descend.

The President. (In French.) — I shall be glad if Mr. Pinto Guzman will forward a note dealing with this matter in detail, this will allow us to give the subject careful attention.

If no one has any special remarks to make on the question of the general slipping of a line, we will deal with the question of the track proper.

In his report, Mr. Henry raised the question of the use of armoured, or reinforced, concrete for strenghthening the bed. It will be interesting if we can have the results of experiments which have been carried out on this point.

In Belgium we have never had to deal with an earth so bad that is has been necessary to use these methods. I would like to mention, however, the case of a particularly bad cutting on the Brussels-Ostend line.

This cutting passed through a bed of « dough-like » clay which has a very bad name in our country. The earth was so bad that not only did the subsoil work up through the ballast, but the line itself became raised and a gradient of 1 in 166 became one of 1 in 125 or even more.

In those days there was no question of using reinforced concrete, and we endeavoured to drain the earth at considerable cost. In the end we determined to remove the clay as far as possible; this is one of the methods recommended in the report. We had looked to removing the clay to a depth of from 10 to 12 inches, but found that we had to excavate to a depth of about 6 ft. 7 in. In one part where the formation rose, the clay has been replaced by stone, which has the double effect of weighting the soil and preventing it from rising and of allowing the water to drain away down the general fall of the incline.

This cutting is today perfectly stable, and the gradient of 1 in 166 is maintained.

I wish to say that today I should not recommend the methods I have described, as they are extremely costly.

Mr. Tintant, Eastern Railway of France. (In French.) — The Eastern Railway has sometimes used beds of concrete. I say « sometimes » advisedly, because the employment of them is very costly, and we only use them in cases of absolute necessity.

We have especially used them in a tunnel where the marly soil is extremely bad. This soil is solid when dry, but when water gets to it it is quickly changed into a sort of mud which works up into the ballast and fills it with dirt. When we have to deal with a hard soil which is not exposed to water, there is no need to use a great thickness of concrete, because the object is only to protect the subsoil from the water which falls from the roof in the tunnels.

We have used the concrete in two forms; in the first place without reinforcement. Experiments were carried out in 1913 with beds 10 to 12 inches in thickness, and these gave good results.

Since then we have made a further trial over a somewhat greater length and under two roads; the distance dealt with being 1 150 feet. In this case the work carried out was more troublesome owing to the excavation and clearing away of the rubbish.

In order to reduce the expense, we have used a thinner bed of concrete — 5 inches in thickness — and we have reinforced it with iron rods 5/16 inch in diameter. We have found at several places, that under the projected bed of reinforced concrete, to a considerable depth, there is marl which had become softened by the action of water; we have removed this soft portion until hard marl has been reached and the portion excavated has been filled in with concrete without reinforcement.

This experiment was made in 1921 and has given such good results that we have been encouraged to use reinforced concrete in place of ordinary concrete with the object of carrying the work out more economically.

The President. (In French.) — Was the work carried out whilst the ordinary traffic was being carried?

Mr. Tintant. (In French.) — Yes, but during the operations single line working was resorted to.

Mr. Quinquet, Paris-Lyons-Mediterranean Railway. (In French.) — We have had the same experience on the Paris-Lyons-Mediterranean Railway with the approaches to the tunnel at Lezines. We found a compact marly soil and so hard that we could only break it up by blasting.

This marl, under the influence of sharp edged ballast of broken stone and the pounding action of the trains, is transformed into mud which works up through the ballast. We have used a bed of concrete to protect the marl against the pounding of the trains, and this work has been carried out without anchoring. After having lifted the line locally, in the interval between trains, or after having supported it by props under the sleepers, we have taken away the road bed until we have reached hard ground, when we have laid a bed of ordinary concrete from 6 to 8 inches thick. After this, in order that the passage of the trains should not break up the concrete, we have spread on it a layer of fine sand 2 inches thick, which allows of the pressure on the ballast being evenly distributed on the concrete. This work was carried out two years ago, and the results have so far been satisfactory.

Mr. Barrand, *vice-president*. (In French.) — Could you tell us what has been the cost of this work?

Mr. Quinquet. (In French.) — I have not with me the actual figures, but I know that the first experiment has been very costly; further trials were carried out under less unfavourable conditions.

The President. (In French.) — By working single line you would have made a sensible reduction in the expense.

Mr. Quinquet. (In French.) — It would have been difficult to have carried the work out in any other manner than the one we adopted on a line where the traffic is as dense as it is between Paris and Lyons.

The President. (In French.) — How long was it before normal working was resumed on the cemented road?

Mr. Quinquet. (In French.) — About a week.

The President. (In French.) — Has anyone else any experiments to communicate to us?

Mr. Tettelin, Northern Railway of

France. (In French.) — The Northern Railway in 1913 carried out similar work in a cutting at Rouge-Barre, where the earth is of the same kind as that mentioned by Mr. Quinquet. There are four lines of rails; we have replaced the top portion of the subsoil by a bed of concrete 8 inches thick with slopes and gutters in it to allow of the water draining off.

In this cutting, which is in the neighbourhood of Lille, on the line between Lille and Mouscron, where formerly water percolated through, we found after the war that the concrete was in a perfect condition without sign of cracking.

We consider that with soils which are likely to become muddy, the use of a bed of concrete will solve the trouble.

The President. (In French.) — I shall be glad if our English and American colleagues will give us the result of their experiences. I think that in America there are a number of cases which should be reported.

Mr. Dreyfuss, French State Railway. (In French.) — The French State has been dealing for a long time with the question of the drainage of cuttings in clay, and is gradually solving the problem.

From the first, and it is twenty years since we began, we have used a cushion of rubble in order to drain the cuttings, but we have not been slow to recognise that the clay tends to work up between the stones.

We have, moreover, recognised that our predecessors had employed, with the same object in view, very fine sand in beds from 6 to 12 inches in thickness, but the result had not been satisfactory, the clay working up in course of time through the bed of sand.

We then thought of using slag, and this is generally employed, being first used on the line from Paris to Chartres, the layer of slag being from 8 to 12 inches in thickness.

We have been completely satisfied; the line, in spite of the increase in the weight of locomotives during the time the work was being carried out, is still in a perfect condition for traffic.

This drainage has been carried out on a line with two roads, the only interference being the slackening of the traffic for the time being.

I should point out, however, that with certain clays, of a specially flowing nature, a bed of cinders, with modern heavy locomotives passing over it, is not sufficient, as trouble will be experienced with the road.

In such cases, which are not of frequent occurrence, we have placed below the layer of slag, a bed of slag concrete from 8 to 12 inches in thickness, made up of 420 lb. of slag cement per cubic yard of slag.

This has given complete satisfaction.

In one exceptional case we have had to construct the line across the soil of an old bog. Here we had to use a series of piles on the heads of which rested a slab of slag concrete, which gave a satisfactory result.

I must apologise for the length of this communication, but I wished to explain how, after twenty years experience, we have arrived at certain conclusions.

The President. (In French.) — We have seen from the report of Mr. Henry that our colleagues on the French railroads have had to overcome difficulties very much greater than those which we meet with in Belgium.

Mr. Henry. (In French.) — It must be borne in mind that we use a light rail.

The President. (In French.) — It is true that, as Mr. Henry remarks, they use

a rather light rail, while in Belgium we employ one weighing 100.80 and even 114.90 lb. per yard.

Mr. Jullien. (In French.) — I should point out that trials made on the Orleans Railway had made us less hopeful with regard to the use of concrete.

When a formation consists of clayey soil which moves easily, the clay tends to assume a sinuous form and the bed of concrete is liable to fracture along the waves.

As long as these waves exist under the sleepers, one is not able to obtain any satisfactory result, because a bed of concrete breaks and the clay passes up through a fracture and work has to be done over again.

The following is the procedure which we actually carry out: We make an excavation through the earth lengthways with the road in such a manner that we get a clear idea of the depth of the layer of clay; we then remove the clay to the level of the bottom of the excavation, leaving the formation with a cambered surface. The excavation is then filled in with fine ashes which are placed in contact with the clay; on these fine ashes we place coarser ones, which bed is made up to that of the ballast. We hope in this way to maintain our track in a good condition.

Mr. Henry. (In French.) — We have introduced at certain points of our road, concrete work in order to protect the ballast from the subsoil.

I would like to mention in addition an interesting case of laying concrete under the track, it has been used on the inverts of the tunnels on the Givet line which passes through quartzites, grits and schists. These inverts were somewhat irregular, and projecting points of rock existed in places. We have covered these unevennesses with a bed of concrete, and we have been able by these means to obtain a uniform thickness of ballast under the sleepers and to do away with the hard running caused by these irregularities. We immediately obtained a considerable reduction in the number of broken rails.

Mr. Andreae, Swiss Federal Postal and Railway Department. (In French.) — I wish to mention that in Switzerland, from the experience we have had, we have arrived at the conclusion that where concrete is in contact with water, its use is not to be recommended in tunnels.

This has been the case in the Hauenstein and Ricken tunnels, the former having been opened for traffic in 1916 and the latter in 1910, and where concrete inverts were employed, the work had to be renewed.

Even when the concrete has a depth of from 10 to 12 inches, the moment that it comes in contact with water it vibrates, as the sleepers do, and these vibrations act as a sort of pump, with the consequence that it causes circulation of water in clayey earths. At the present time the Swiss Federal Railway, where they find it necessary to protect the subsoil from water or the ballast from the formation underneath, notably in tunnels, prefer to give the subsoil the form of an inverted arch.

These arches were formerly constructed of concrete and did not give satisfactory results. Our specifications now invariably require the use of ashlar masonry, after the excavation has been given the true form of the invert by means of concrete.

Mr. Quinquet. (In French.) — In order to be able, during the war, to rapidly transport coal to Italy, where a shortage existed, we drove a tunnel under a part

of the City of Marseilles; the footings of this tunnel are constructed of masonry and the arch of concrete.

In order to avoid the top arch cracking, it was arranged for the arch to spring from squared masonry voussoirs, the joints of which were kept dry during the construction and afterwards filled up with mortar. In the same way the keystone of the arch has been made of stone with articulated joints. The concrete of the arch being well rammed between the stone voussoirs and keystones. By this method we have prevented cracks during construction. It has allowed the work to be carried out rapidly, and from that point of view the means we adopted have been very effectual; it is certain, in fact, that the construction of a masonry arch would have taken considerably more time. It should be noted that we passed under houses at a depth of 16 ft. 5 in., but in spite of this, we have not had the slightest accident.

A delegate. (In French.) — In what kind of earth were you working?

M. Quinquet. (In French.) — In soft clay and marl.

For solidifying the track in clay cuttings we have obtained excellent results by protecting the formation by a bed of fine material (sand or screened ashes) in order to prevent the pieces of angular stone or sharp edged broken stone ballast coming in contact with the clay.

Whilst the line was being doubled between Mouchard and Pontarlier, we found at one point the new formation so bad that the contractor's line sank in the clay up to the top of the rails. I immediately gave orders to drain this formation, using locomotive ashes. As it seemed evident to me that the formation under the old line was also of bad clay, I gave instructions for it to be drained in the same manner. An inspector who had had charge of the maintenance of this part of the line informed me that this was unnecessary as the old line was perfectly stable.

I was anxious to ascertain the reason for this stability, and I gave instructions that the traffic should be worked on the new line and the old line and its ballast be removed. I then discovered that under the top bed of broken stone ballast was an old bed of gravel ballast which lay on a bed of very fine sand 6 inches thick. This extended the whole length of the sleepers and was what had prevented the clay being affected by the hammering of the trains. This state of things had existed for twenty-eight years and dated from a time when the use of gravel ballast was abandoned for ballast of broken stones.

Let me give another example :

Between Dijon and Dôle we have six cuttings; in three of these the line is nearly stable and in the other three it is in movement. I was anxious to get an explanation of this, and I found that wherever the road was stable, the ballast of broken stone was laid on sand which separated it from the clay, and on the other hand, wherever there was movement, the broken stone was in contact with the clay. From this one gathers that it is inadvisable to place broken stone in direct contact with clay.

Mr. Henry. (In French.) — On the line from Paris to Nancy we have come to the same conclusion. When we removed the old ballast, which was of a very fine nature, and replaced it with broken stone, we had in a very short time to do the work over again and lay the ballast with a sandy bed underneath.

Mr. Quinquet. (In French.) — Another method has been employed between Dijon

and Saint-Amour which has been in use about thirty years. It consists in placing outside the ends of the sleepers dwarf concrete walls 1 ft. 8 in. in thickness which go down to the firm clay, the top being level with the top of the formation. With double lines, in place of putting two thin walls between the roads, one wall is constructed 2 ft. 7 1/2 in. in thickness and placed clear of the sleepers between the tracks.

The track is therefore held between these dwarf walls.

The engineer of this line, knowing that I was interested in this question, suggested that I should go and see what had been done in these cuttings which are 20 in number. I have been satisfied that the road is held in a perfect condition.

This method has been employed since on other portions of the railway.

I am not satisfied to simply state the result (but would like to give details). At first sight one would ask how it could possibly be that the roads were not affected owing to the water trapped between the dwarf walls. I found the explanation by visiting, several days after, cuttings, in the neighbourhood of Besançon, which had been drained by means of fine ashes. Here this method had been successful at certain places, but had failed at others. It has been successful where the bed of ashes rests on firm clay. It has failed at certain places where, owing to the deep sinking of the ballast, one has not been able to prepare the new formation at the deepest level except at an excessive cost. At the points where the sinking was exceptional, orders were given to clean out the deep pockets thoroughly down to the solid and to fill them with puddle up to the lowest level fixed for the new formation. In certain places, however, this repair has been carried out badly, and the puddle rested, not on firm clay, but on a thin bed of muddy clay. At these points the puddle, resting on a moving base, has been forced out laterally with such pressure, owing to the passage of the trains, that it has been raised vertically along the masonry walls which form the inner sides of the cutting. This result causes me to believe that the dwarf walls on the Dijon-Saint-Amour line have resulted in preventing the clay held by these walls being forced out laterally by the pressure of the trains. We have 4.4 miles of cuttings of this kind which have been in service for thirty-four years, 3.7 miles for thirty years, and 5.6 miles for twenty-five years.

Can one say that this system is a panacea for all ills? No, because with the constantly increasing weight of locomotives one cannot say that it will answer in fresh circumstances.

Whatever happens, the method is interesting owing to the fact that the work can be carried out without interfering with the running of the trains. The walls having been built, all that will be required in the second stage should this become necessary will be the emptying of the water pocket between the walls and filling it with very fine ashes; this can be done when it is necessary for the ballast to be renewed. (*Applause.*)

Meeting held on 19 April 1922 (afternoon).

Mr. BRUNEEL, IN THE CHAIR.

The President. (In French.) — First of all I would like to express a thought that has been running through my mind. Up till now we have had considerable discussion, but it has always been our French colleagues and your President who have taken part in it. Our English colleagues have only taken a very modest part in our debate, whilst we have none of our American colleagues with us. I would like to press on them very strongly the desire we have that they will join in the discussion, and I have no doubt but that their contributions will be very interesting and very well received. (*Applause.*)

I would add that we ought not only to discuss, but to exchange views. If some members are prevented from speaking for fear of not being able to express themselves in a manner satisfactory to themselves in a language they are not familiar with, I trust they will no longer hesitate to speak. We shall be grateful to them if they will.

Having said this, Gentlemen, we will pass on from the consideration of clayey formation to the question of *an intermediate bed of ashes or fine sand between the formation and the ballast or between the bed of concrete and the ballast.*

This question has been dealt with by our American colleagues, and it would be very interesting to know the result of their experience.

Everyone is perfectly in accord as to the advantage of an intermediate bed of ashes or fine sand. (*Agreed.*)

Then there is the question of packing the track; our colleagues on the Northern Railway of France have since the war adopted a system of shovel packing and this system is also I think practiced in England.

Mr. Paris, Northern Railway of France. (In French.) — We are able to say that in England this system of packing is practiced frequently and with success.

A characteristic of English roads is the total absence of weeds, and this shows that when the ballast and the formation are isolated, it is impossible for the weeds to grow.

Mr. Trench, *reporter.* — In England it has not been found necessary to use concrete beds; even the most unstable clay formations have been successfully dealt with by means of a thorough system of drainage and by placing under the ballast a suitable layer of ashes or sand. I note the favourable results which have been obtained in France by means of longitudinal dwarf walls, a method of which I was ignorant. I mention in passing the advantages obtained by « shovel packing » for consolidating the sleeper beds. This method originated in England, but has now been adopted by the Nord and other French railways, and is described fully at the end of the paragraph dealing with ballast in my paper.

Mr. Jullien. (In French.) — It would I think be interesting to ask Mr. Trench if, when discussing longitudinal walls, he is giving us his personal opinion, or the results of experience.

Has their behaviour on the London & North Western Railway given good results?

Mr. Trench. — No experiments have been made with small longitudinal walls on the London & North Western Railway.

The President. (In French.) — Let us pass on, Gentlemen, to the subject of rails.

In Mr. Trench's report one finds a comparison between the English double headed rail and the Vignoles rail.

This question has been discussed at various times and at the Paris Congress in 1889 I had the honour of being the reporter on this subject.

At that time, although my administration used the Vignoles rail, I came to a conclusion in favour of the double headed rail for roads run over at very high speeds.

I ask our French colleagues to tell us if the double headed rail continues to be used today on certain of their railroads where they have standardised their rails.

Mr. Jullien. (In French.) — In France there are six railways. Three use flat bottom rails which necessitates the use of oak sleepers, whilst three roads — one of which is the Orleans — employ double headed rails which allows softer wood to be used for the sleepers.

The Orleans Company is working towards the Vignoles rail which offers the advantage of giving greater facilities for constructing points and crossings.

The President. (In French.) — The question is not on our order of the day, we cannot therefore, without infringing the standing orders, discuss it thoroughly.

In 1889, the Congress decided in principle in favour of the double headed rail for lines on which numerous and heavy trains run over at very high speeds; questions of this kind, however, must largely influence the choice made.

With regard to the length of the rails, we are all in agreement in recommending that the long rail should be used on account of the advantages it offers.

In Belgium, the normal length is 59 feet.

Rails of 78 ft. 8 in. are used occasionally on metal bridges in order to avoid joints on the superstructure and consequent hammering.

Mr. Willem, Belgian State Railway. (In French.) — For crossing metal bridges the Belgian State uses rails of a greater length than the normal one of 59 feet. These do not, however, exceed 98 ft. 5 in., because of the difficulties which the works in the country encounter in handling during manufacture and in loading them.

Mr. Jullien. (In French.) — There is also the question of the expansion in very hot weather to be considered. 59 feet is a reasonable limit for running lines; on bridges it is perhaps desirable to go to 78 ft. 8 in. for the reasons stated by the President; on running lines, however, to go beyond 59 feet, seems to me to be dangerous, because the liability to deformation is increased.

On the Orleans Railway we have had grave trouble resulting from expansion.

The President. (In French.) — What is the length of the rail in Czecho-Slovakia?

Mr. Deyl, *vice-president.* (In French.) — We go to about 49 ft. 3 in.

The President. (In French.) — In Belgium we have successively adopted lengths of 19 ft. 8 in., 39 ft. 4 in. and now 59 feet.

In one of the reports, I read that on certain railways the distance between the centre of the roads is 13 ft. 2 in., which implies that it is 8 ft. 2 1/2 in. between the rails. I do not think that this can be the current practice.

In Belgium, France and England, the distance between adjacent tracks is 6 ft. 6 3/4 in., and in Belgium up to 9 ft. 1/4 in. in certain special stations in order that two carriage doors may be opened opposite one another without causing accident.

We should be glad if our colleagues,

whose administrations have 13 ft. 2 in. between the centres of the lines, would tell us if this dimension has been adopted for special important reasons, as it involves considerable expense?

I also read in one of the reports a phrase which surprised me a little. It is stated that on the Pennsylvania Railroad the screws and spikes should not press the bottom of the rail against the sleeper, but allow a little play. Has this practice been generally followed by the railroads? In France, England and Belgium we endeavour to make the attachment as firm as possible.

Mr. Paris. (In French.) — During the war we had to use spikes on the railways. These spikes, however, before long worked up from the foot of the rail. As soon as we could replace these spikes with screws we did so. Since we have been able to use screws well screwed down, the troubles we experienced have disappeared.

The President. (In French.) — If I am not mistaken, the spikes used during the war were of a primitive character.

Mr. Paris. (In French.) — At certain level crossings we found that the check rails broke up the pitching; the fish plates were broken and the joints of the rails rose about 1 5/8 inches.

Mr. Willem. (In French.) — In Belgium, since the war, we have found on certain lines that rail creep took place to a serious extent.

Mr. Henry. (In French.) — This has also been the case on the Eastern Railway of France, even when screws have been used for holding the rails down.

Mr. Paris. (In French.) — This shows the importance of the screws always being kept well tightened. Twice a year an inspection should be made to see that the tightness of the screws leaves nothing to be desired, moreover, one must deal very severely with any negligence on the part of the personnel which can be brought home to them.

Mr. Tintant. (In French.) — I trust that our English speaking colleagues will give us their opinion of the two methods of fastening the rail, that is to say, with screws, as is our custom, or with spikes, as is done in America.

Mr. Grierson, Great Western Railway. — The practice in force in various countries in regard to the width of formation and the slopes of the cuttings and embankments does not appear to vary greatly, and the necessity for efficiently draining the formation and of usihg suitable ballast has, no doubt, long been well understood.

I think that one of the most useful points to which attention has been called in these papers is the necessity to provide for a thickness of ballast sufficient to efficiently distribute the weight of the rolling loads, and the trials made on the Pennsylvania Railway are exceedingly interesting in this respect.

The weights of locomotives have, for the most part, greatly increased since the original construction of most of our railways, and to instance the railway with which I am personally concerned, *viz.*, the Great Western Railway, I have not the least doubt but that there must be long sections, more particularly in soft strata, where the formation as originally constructed is now entirely deformed, so that the camber has entirely disappeared, depressions probably formed, and the drainage consequently greatly interfered with. The question is one to which, in my opinion, engineers would advantageously give greater consideration in the future when constructing new railways,

and while it is a difficult and expensive matter to reconstruct an existing formation, opportunities sometimes occur, during extensive relaying operations, to carry out such work more economically, and, in many cases, such expenditure would, in my opinion, be justified.

In one respect there is very considerable difference between the practice in Great Britain on the one hand, and on the Continent and, to a large extent, in America on the other hand. In Great Britain, a chaired road with a bull-head rail is almost entirely used, while on the Continent and in America, the use of a flat-bottom rail resting either directly on the sleepers or on some form of packing such as a steel sole-plate greatly predominates. Great Britain has to import a very large proportion of the sleepers used, and, consequently, their cost is a material factor in the total cost of the track. Steel sole-plates do not afford the same bearing area on the sleepers as chairs can be designed to do, and, consequently, the use of chairs reduces the number of sleepers that would otherwise be necessary, and, for a first class road required to meet the needs of a heavy and fast traffic, the cost of the chaired road in Great Britain is not greater than that of a suitable flat-bottom track. The conditions as regards the availability of home grown timber are more favourable in some countries, and where hardwood, such as oak, is available at a moderate price, thereby dispensing, possibly, with the need for a steel sole-plate, the cost of flat-bottom track is considerably reduced. The question of the suitability of the two types of road for different countries would appear to largely turn on local conditions, and the extent and requirements of the traffic.

Mr. Tintant. (In French.) — I would like to have the opinion of the Americans. The English have never used spikes, but American engineers attribute to them certain advantages, which we should like to hear about.

The President. (In French.) — We are getting to the end of this discussion. We have only to deal with several subsidiary subjects.

One of these is the thickness of the ballast. What it is composed of depends on local resources.

In Belgium, we use for ballast, stone. The harder it is, the smaller it may be broken. Our specification lays down that the stone ought to be broken to pass through a ring of 3/4 and 1 1/2 inches in diameter for rock which we call « porphyre », and is in reality a very hard diorite quartzite, when a softer grit stone is used it should go through a ring of 2 3/8 inches diameter.

Mr. Paris. (In French.) — In England, from what we have seen, it is generally 2 inches.

Mr. Dreyfuss. (In French.) — On the French State Railways we use 3 inches, and for economical reasons go up to 4 inches.

The President. (In French.) — Is this for slag?

Mr. Dreyfuss. (In French.) — No, for broken stone.

Mr. Deyl, *vice-president.* (In French.) — I have laid on the table a note recommending, as a test for ballast, a method drawn up by Mr K. Špaček, professor at the Institute of Prague.

The President. (In French.) — This note will be published as an appendix to the discussion. (See appendix 3.)

I believe that I am right in saying that the size of ballast generally approved of is from 3/4 to 1 1/2 inches. (*Agreed.*)

The question of the spacing of the sleepers has not been discussed. There are different formulæ dealing with this; generally the thickness of the ballast is equal to the distance between the centre of the sleepers. In Belgium, for a rail of 81.95 lb. per yard we have adopted a spacing for the sleepers of 2 ft. 4 3/4 in. I should add that we use sleepers perhaps rather wider than employed elsewhere, at least for roads on which the trains run at high speeds. Our sleepers are of the half round type and 11 inches across the base and 5 1/2 inches thick.

This results in the distance between the edges of the sleepers being small.

Mr. Willem. (In French.) — It would be interesting to hear why, in France they prefer, in place of half round sleepers 11 inches wide, sawn sleepers 9 1/2 inches wide, a type which necessitates the cutting away of a slab of wood from each side. It is evident that the cutting away of this slab lessens the bearing area of the sleeper and causes additional work.

The President. (In French.) — Will someone tell us why in France a slab of wood is taken off each side of the sleeper?

Mr. Quinquet. (In French.) — Generally this is done by the timber merchant who takes off this portion of the sleeper and thus produces outside slabs, which are found easy to use up for fencing or for any other similar work.

The President. (In French.) — This is the explanation.

There is another question that we should consider, and that is the position of the joints in the rail; should they be staggered or opposite one another? There is no settled opinion in Belgium. Dependent on the type of rail, sometimes the joints are placed opposite one another and sometimes staggered. There is not a well settled conviction as to the advantages of the one or the disadvantages of the other.

Mr. Jullien. (In French.) — We have arrived at the conclusion that staggered joints ought not to be used because of the swaying action they create in the vehicles.

Mr. Paris. (In French.) — We have employed staggered joints, but have given them up.

Mr. Jullien. (In French.) — The Northern Railway of France used to stagger the rail joints on lines on which high speeds were employed. This Company has given them up because they gave to the vehicles a swaying motion, causing great discomfort to passengers.

Mr. Willem. (In French.) — The question of the joint is closely bound up with that of the fish plates. If these are made strong and solid, shocks are diminished.

Mr. Trench, *reporter.* — As to whether the rail joints should be placed opposite one another or staggered, there is still some difference of opinion, but the great consensus of opinion is now in favour of square joints. Some engineers hold that on sharp curves staggered joints hold the rails in better line, but for ordinary plain road, it is generally accepted amongst English engineers that square joints give better running, particularly when special precautions are taken to reinforce the track by using joint sleepers of larger size, and by laying the sleepers on each side of the joints closer together.

Mr. Willem. (In French.) — Is there anyone who is able to give us information with regard to the inclination of the rails?

Mr. Henry. (In French.) — In France,

we have adopted, at the same time as the rail itself was standardised, the vertical position; we based this on what we believed to be the American practice. Six months after we learnt that the Americans had given up this practice.

Mr. Tettelin made a report which showed us how closely the Americans had gone into the question of the vertical position, but that they had returned to the inclination of 1 in 20.

We have now in our turn given up the vertical position, which had at once shown itself to be unsatisfactory, and returned to an inclination of 1 in 20.

The President. (In French.) — In Belgium, we have the rails inclined 1 in 20. When, however, thirty five years ago the 104.83 lb. per yard type of rail was brought in, we found difficulties with the points and crossings, and it was decided to again place the rails vertically, in the opinion that after use, the rolling line should be reported towards the centre of the rail.

Mr. Henry. (In French.) — In France, we have found that the vertical position causes a ridge on the top portion of the rail on the side nearest the centre of the track.

Mr. Willem. (In French.) — In Belgium, on our curves, we have found the wear to be normal.

The President. (In French.) — We have, Gentlemen, to prepare for the full session, a résumé of this discussion.

In the summary which we have to make, there is one point which should take first place. This is, that in spite of the increased weight per axle and the increase of speed, the maintenance on the various railroads has not become more difficult or more onerous than formerly. This is due to the improvements which have been made in laying the track.

In reality, we have also found that everything depends on the care taken in first laying the track, and we have found this knowledge very useful.

Mr. Dreyfuss. (In French.) — It seems to me, however, that at our meeting this morning, it was stated that the increase of load and speed lead to fractures. Is it not a fact that these cause an increase in expenditure?

The President. (In French.) — I meant only the increase of running repairs of the railroad.

Mr. Dreyfuss. (In French.) — In addition to the necessary repairs and their expense, it is necessary to expend considerable amounts, not only to the track, but on the ballast, owing to the increase in the weight of the locomotives and in the speed of the trains. It is especially noticeable that the renewal of the ballast has to be done sooner, and this fact is in close connection with the increase of speed.

The President. (In French.) — That is nothing else than a question of men. Are your gangs large enough?

Mr. Dreyfuss. (In French.) — It is a relative matter. Our gangs, as far as numbers are concerned, are not larger than previously. They take twice as long doing the work.

Mr. Jullien. (In French.) — For about twenty years I had the repair of the line from Tours to Bordeaux under my charge. At that time we had not such heavy locomotives as there are today. Clay did not work up through the road one might say at any point. Now at a number of places we have had to remove the clay and carry out draining work.

We have minimised the increase of

expenditure which resulted, by taking steps to make the work of the gang easier. For this reason we do not now completely cover the sleepers, and this lightens the work.

Mr. Tintant. (In French.) — Everyone is agreed that the work is not more difficult, but can it be said that it is not more arduous.

It is hardly likely that one is able to maintain at the same cost a road on which the traffic is heavy, and one which only has to deal with a light traffic.

Everyone will agree if we say that the maintenance is not more difficult, but that it is to a certain extent more onerous, and that the expense increases, in all cases, in proportion to the traffic.

Mr. Henry. (In French.) — I think that before we decide on the summary of the discussion on question I, it will be advantageous to discuss question II. (*Cries of approval.*)

The President. (In French.) — It is agreed that we will deal later with the summary that Mr. Henry will be good enough to draw up after we have finished this discussion on question II.

Meeting held on 24 April 1922 (morning).

Mr. BRUNEEL, IN THE CHAIR.

The President. (In French.) — Since our last meeting, the Permanent Commission of the Congress have met to deal with the statutes of the Association, which will be submitted to the General meeting.

In the course of this meeting, one of the oldest members of the Congress called attention to the fact that originally reporters were not allowed to draw up « Conclusions ». The sectional meetings and the General meetings on their part were not asked to draw up « Conclusions », but gradually the sections have drawn up these « Conclusions », and in this form have asked the General meeting to ratify them.

The wish was expressed that the term « Conclusion » should not be used, probably because it was feared that the various authorities in control of the railways might, through its use, insist on certain methods, which we had suggested, being installed, and thus causing more or less considerable expense. It was decided that the term « resume » or « summary » should be used, and that we should say « The section states that... »

Mr. Tronconi, *principal secretary,* read the report of the discussion which had taken place on question I [1].

— This report was adopted.

Mr. Henry, *special reporter,* read the summary relating to this question :

« During the past ten years the maximum speed of trains has not been increased, but there has been a considerable increase in the number of trains travelling at high speed, and this applies more particularly to goods trains.

« The weight of trains have also increased appreciably as have the axle loads. Some mineral trains now impose on the track loads which are comparable with trains composed entirely of locomotive engines.

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(1) This report is reproduced hereafter, in the discussion at the general meeting, page 102.

« The passing of these greater loads at high speed has resulted in increased wear and tear of the track, but so far these conditions have not increased appreciably the cost of ordinary maintenance.

« The increased wear and tear has been successfully dealt with : 1° by undertaking in good time all necessary repairs; 2° by carrying out the relaying of the track at shorter intervals, and 3° by taking such steps as are necessary to equalise as far as possible the distribution of pressure on the roadbed.

« When relaying the track it is not unusual to adopt one or all of the following improvements :

« 1° To increase the depth of the ballast;

« 2° To increase the number of sleepers;

« 3° To lay down rails of greater weight.

« In the construction of new lines, the following measures are recommended:

« *Road bed.* — Every effort should be made to secure the greatest stability of the roadbed by means of efficient drainage in the cuttings and on embankments by selecting the best available material for the upper portion of the embankments.

« In certain cases where the formation is particularly unstable, a layer of concrete has been laid down under the ballast. Some engineers report favourably on this method of construction, others are doubtful of its value. In any case the cost is exceedingly high.

« If intercepting side drains are used to prevent sub-soil water from gaining access to cuttings, these drains should be of large size.

« *Ballast.* — The total thickness of top and bottom ballast should depend on the solidity of the roadbed. It should vary from 1 to 2 feet below the sleepers, the two layers being divided into suitable proportions.

« The bottom ballast should consist of permeable material, which, while providing free drainage for surface water, will still be sufficiently close to prevent clay working up through the ballast.

« The choice of material for top ballast must depend on the resources of the district. The best appear to be hard stone or furnace slag broken to suitable size. Where gravel is used, it should include from 12 to 14 % of broken pebbles, and from 20 to 25 % of sand. The thickness under the sleepers should be not less than from 6 to 8 inches.

« *Sleepers.* — For the flat bottomed rail, the spacing of sleepers should be as a rule 2 ft. 2 1/4 in. between sleepers. For chaired road 2 ft. 7 1/2 in. between sleepers.

« *Rails.* — The minimum weight of rails should be 72 lb. per yard.

« For more important lines : 92 to 100 lb. per yard.

« Some American Companies have, on lines of heavy traffic, laid down rails weighing 130 lb. per yard; this has allowed them to use high carbon steels.

« For tunnels, rails of about 110 lb. per yard are recommended. »

The President. (In French.) — The discussion is open. If no one wishes to speak, I declare this wording adopted.

I wish to thank Mr. Henry, the special reporter, for the care with which he has carried out his difficult task.

The wording which he has put before us represents, I believe, very perfectly the discussion which has taken place.

It will be submitted to the General meeting.

DISCUSSION AT THE GENERAL MEETING

Meeting held on 26 April 1922 (afternoon).

Mr. R. DE CORNÉ, HONORARY VICE PRESIDENT, IN THE CHAIR.
GENERAL SECRETARIES : Mr. J. VERDEYEN; Mr. E. FRANZA; Sir HENRY FOWLER.
ASSISTANT GENERAL SECRETARY : Mr. N. GIOVENE.

Sir Henry Fowler, *general secretary*, read the

Report of the 1st section.

« (See *Daily Journal of the session*, No. 6, p. 8.)

« Mr. BRUNEEL opened the discusion on question I, and called upon Mr. HENRY (*special reporter*) who read a summary which he had prepared of the reports of Messrs. Mudge, Ewing, Henry and Candelier, Ahlberg and Trench.

« THE PRESIDENT pointed out to the reporter that each of them was at liberty to raise any objection he liked to Mr. Henry's summary. In the meantime he pointed out that the subject naturally divided itself into two parts, namely :

« 1° Strengthening the track;
« 2° The road bed.

« Dealing with the first of these he called upon Mr. Ahlberg (*reporter*) to make some supplementary remarks with regard to the method of hastening the settlement of embankments on very soft clay which he had mentioned in his report. He also asked if the French translation of his report (No. 4) expressed fully his ideas.

« Mr. AHLBERG stated the method described in his report for hastening the settling down of embankments on very soft clay had been used several times in Sweden, where such ground was found, considerable settlement had in this way been quickly obtained which allowed the embankment to reach the firm sub-soil by the lateral displacement of soft clay. At one particular point the embankment had sunk from 13 to 16 feet.

« Mr. HENRY dealt with the use of intercepting side drains for cuttings, these he stated finally became choked and caused water pockets, resulting in bad slips. He did not recommend the system unless the drains are made of sufficient size to allow of easy inspection.

« THE PRESIDENT mentioned the successful application of this type of drain used during the construction of a line through very wet ground across the old war front.

« Mr. BARRAND (*French Government*) stated that he had seen a number of plans sent in to the Bridges and Roads Department for the consolidation of slips caused by these drains.

« Mr. GUZMAN (*Ecuador Government*) spoke of the difficulties he had experienced during the construction of a railway on volcanic ground of such an unstable

nature that they were hardly able to advance a yard in three months.

« The President then opened the discussion on the method of strengthening the track by the use of concrete or ferro-concrete. In Belgium they had not found many cases where this was necessary. He called to mind however a particular case of a section of the Brussels-Ostend line which crossed a bed of « paniselienne » clay. The clay sub-soil worked up through the ballast, and had to be excavated for a depth of about 6 1/2 feet and replaced by good earth.

« Mr. Tintant (*Eastern Railway of France*) stated that beds of concrete are used by them in tunnels where the soil is of a clayey nature and softened by water. These were of two kinds :

« 1° A slab of concrete without reinforcement, 10 to 12 inches thick;

« 2° A slab of reinforced concrete of about half this thickness.

« The Eastern Company decided to use this second solution in order to reduce the surplus expense in earth work; this work was carried out under one road whilst the traffic was carried over the other line.

« Mr. Quinquet (*Paris, Lyons & Mediterranean Railway*) spoke of the running of an open trench in a marl sub-soil. He also mentioned the use of a concrete bed without anchorage — this was covered with a layer of sand two inches in thickness, which allowed for the distribution of the pressure of the ballast on to the concrete. This work was carried out two years ago, and they were still awaiting the results of the experiment.

« Mr. Dreyfuss (*French State Railway*) detailed the work of consolidation of road bed which had been carried out on the French State Railway.

« Mr. Tettelin (*Northern Railway of France*) mentioned that in 1913 they had used a bed of concrete under a road having four tracks. The line had stood up to its work very well, and he concluded that with ground which became muddy when wet (loamy clay) a bed of this description solved the difficulty.

« Mr. Jullien (*Paris-Orleans Railway*) was rather pessimistic with regard to what had been said, and pointed out that clay tended to take a sinuous form with the result that the concrete broke by the hollow places. In place of the operations described he preferred to clear the soil away and make a bed in the form of a saddle back filling the excavation with fine ashes upon which a thick bed of ashes was put for the ballast to be placed on.

« Mr. Andreae (*Swiss Government*) remarked that in tunnels they had found that it was better to use an inverted arch of ordinary masonry, a concrete slab did not give good results.

« Mr. Quinquet called attention to the fact, which also stated Mr. Ewing (*reporter*), that it was not advisable to put broken stone in contact with marl. He spoke of his experience in using longitudinal dwarf walls for consolidating the road bed, the use of which had proved very satisfactory.

« The President raised the point of the employment of an intermediate layer of ashes or fine sand, and asked the English speaking delegates if they would give their experience of this method of construction.

« Mr. Trench (*reporter*) stated that in England it had not been found necessary to use concrete beds, even the most unstable clay formations had been successfully dealt with by means of a thorough

system of drainage and by placing under the ballast a suitable layer of ashes or sand. He noted the favourable results which had been obtained in France by means of longitudinal dwarf walls, a method of which he was ignorant. He mentioned in passing the advantages obtained by « shovel packing » for consolidating the sleeper beds. This method originated in England, but has now been adopted by the Northern and other French railways.

« Mr. Jullien stated three of the six railway systems in France used the flat bottom rail, and three, including the Paris-Orleans Company, a double-headed rail, which by means of chairs allowed the use of soft wood sleepers; he added his Company were leaning towards the adaptation of the Vignoles rail, owing to the simplification of the attachments in point and crossing work.

« The President called attention to the advantages of long rails; the standard rail in Belgium is 59 feet, but longer rails (78 ft. 8 in.) are also laid down where it is advantageous to reduce the number of joints as for instance on iron bridges.

« Mr. Jullien drew attention to the fact that if the rail exceeded 59 feet, deformation might be caused in some cases.

« Mr. Deyl (*Czecho-Slovakia State Railway*) said their practice was to use a 49 ft. 3 in. rail.

Mr. Grierson (*Great Western Railway*) pointed out that the question of the drainage of the road bed is generally well understood. He went on to make several general remarks on the methods employed in building up the track. In his opinion the fastening down of the rail by means of spikes was not a good one; unfortunately there was no delegate from the United States present at the meeting who could have answered Mr. Tintant's question as to the advantages which American Engineers attributed to this method of fastening which is the one usually adopted by the majority of American railways.

« Mr. Deyl recommended the test of the ballast which had been brought out by Professor Špaček of the Prague Institute.

« The President raised the question of the relative merits of the two systems of laying the rails — with joints opposite one another or with joints broken — mentioning that in Belgium both methods were employed.

« Mr. Jullien considered that the method of using broken joints would have to be abandoned owing to the swaying action which it caused in the coaches.

« The final discussion dealt with the points as to whether rails should be laid vertically or inclined inwards 1 in 20.

« Mr. Henry stated that in France they had reverted to laying rails at an incline of 1 in 20, and the tendency appeared to be the same in America. If the rails were laid vertically, there is a tendency to unequal wear at the head of the rail. »

The President. — This is the

Final summary.

« During the past ten years the maxi-
« mum speed of trains has not been in-
« creased, but there has been a consider-
« able increase in the number of trains
« travelling at high speed, and this
« applies more particularly to goods
« trains.

« The weight of trains have also in-
« creased appreciably as have the axle
« loads. Some mineral trains now im-
« pose on the track loads which are com-
« parable with trains composed entirely
« of locomotive engines.

« The passing of these greater loads at « high speed has resulted in increased « wear and tear of the track, but so far « these conditions have not increased « appreciably the cost of ordinary main- « tenance.

« The increased wear and tear has been « successfully dealt with : 1° by under- « taking in good time all necessary re- « pairs; 2° by carrying out the relaying « of the track at shorter intervals, and « 3° by taking such steps as are neces- « sary to equalise as far as possible the « distribution of pressure on the roadbed.

« When relaying the track it is not « unusual to adopt one or all of the fol- « lowing improvements :

« 1° To increase the depth of the bal- « last;

« 2° To increase the number of sleep- « ers;

« 3° To lay down rails of greater « weight.

« In the construction of new lines, the « following measures are recommended :

« *Road bed.* — Every effort should be « made to secure the greatest stability « of the roadbed by means of efficient « drainage in the cuttings and on em- « bankments by selecting the best avail- « able material for the upper portion of « the embankments.

« In certain cases where the formation « is particularly unstable, a layer of « concrete has been laid down under the « ballast. Some engineers report favour- « ably on this method of construction, « others are doubtful of its value. In any « case the cost is exceedingly high.

« If intercepting side drains are used « to prevent sub-soil water from gaining « access to cuttings, these drains should « be of large size.

« *Ballast.* — The total thickness of top « and bottom ballast should depend on « the solidity of the roadbed. It should « vary from 1 to 2 feet below the sleepers, « the two layers being divided into suit- « able proportions.

« The bottom ballast should consist of « permeable material, which, while prov- « iding free drainage for surface water, « will still be sufficiently close to prevent « clay working up through the ballast.

« The choice of material for top bal- « last must depend on the resources of « the district. The best appear to be « hard stone or furnace slag broken to « suitable size. Where gravel is used, it « should include from 12 to 14 % of « broken pebbles, and from 20 to 25 % « of sand. The thickness under the « sleepers should be not less than from « 6 to 8 inches.

« *Sleepers.* — For the flat bottomed « rail, the spacing of sleepers should be « as a rule 2 ft. 2 1/4 in. between sleepers. « For chaired road 2 ft. 7 1/2 in. between « sleepers.

« *Rails.* — The minimum weight of « rails should be 72 lb. per yard.

« For more important lines : 92 to « 100 lb. per yard.

« Some American Companies have, on « lines of heavy traffic, laid down rails « weighing 130 lb. per yard; this has « allowed them to use high carbon steels.

« For tunnels, rails of about 110 lb. « per yard are recommended. »

— The general meeting ratified this summary.

[625 .14 (01]

APPENDIX 1.

SUPPLEMENT TO REPORT No. 5 [1]

(Great Britain)

ON THE QUESTION OF THE ROAD BED AND OF THE TRACK (SUBJECT I FOR DISCUSSION AT THE NINTH CONGRESS OF THE INTERNATIONAL RAILWAY ASSOCIATION),

By E. F. C. TRENCH,
ENGINEER IN CHIEF, LONDON & NORTH WESTERN RAILWAY.

Answers of the Midland Railway and the East Indian Railway to the detailed list of questions relating to question I.

Midland Railway . . . = M. R. | East Indian Railway. . . = E. I.

I. — General conditions.

Please give :

(a) *Maximum speed run on :*

(1) *Main lines :*

E. I. 60 miles per hour.

(2) *Secondary lines :*

E. I. 30 miles per hour.

(b) *Maximum weight of :*

(1) *Passenger trains :*

E. I. 536.25 tons (including engine and tender).

(2) *Goods trains :*

E. I. 1 936.25 tons (including engine and tender).

(c) *Maximum weight of engine used on each class of line :*

E. I. Main lines : 136.25 tons.
Secondary lines : 107.04 tons.

(d) *Maximum axle load.*

E. I. 17.4 tons.

(e) *How do the maximum engine weights and axle loads of to-day compare with those existing on your railway 10 years ago.*

E. I. Engine and tender: in 1910, 107.04 tons; in 1920, 136.25 tons.
Axle loads : in 1910, 16.05 tons; in 1920, 17.4 tons.

(f) *If your railway is subject to adverse climatic conditions, please state what special precautions you take.*

E. I. and M. R. Nil.

II — Road Bed.

(a) *What is your standard width of formation :*

(1) *On banks :*

M. R. Single, 19 feet; double, 33 feet.
E. I. Single, 20 feet; double, 34 feet.

(1) See *Bulletin of the International Railway Association*, number for August 1921, p. 991.

(2) *In cuttings?*

M. R. Single, 16 feet; double, 30 feet.

E. I. Single, 18 feet; double, 32 feet.

(b) *Is the formation level transversely or is it cambered :*

(1) *Where the railway is straight;*

(2) *Where the railway is curved?*

M. R. Cambered in cutting, level on embankment.

E. I. Cambered.

(c) *What is your practice as to draining the formation :*

(1) *On banks;*

(2) *In cuttings?*

Please supply sketches.

M. R. By side and cross drains where necessary.

E. I. By open drains at top and bottom of slopes of cuttings and at foot of banks.

(d) *What special steps do you take when the railway crosses marshy or boggy land?*

E. I. None required.

(e) *Do you find it necessary to limit the speed of trains in crossing marshy or boggy land?*

. . . .

(f) *What special precaution do you take to deal with lines which are liable to subsidence through the working of minerals or the pumping of brine?*

M. R. By longitudinal timbering, slackening of trains and special watching.

E. I. No trouble on main lines. On branch lines, speed of trains reduced, length patrolled and night traffic as a rule prohibited. No experience of subsidences due to pumping brine.

(g) *Is it your practice to limit speeds under these circumstances? And if so, what speeds to you allow?*

M. R. Yes, 5 miles per hour.

E. I. Yes, about 5 miles per hour.

(h) *How do you usually deal with slips when they occur :*

(1) *In banks;*

(2) *In cuttings?*

M. R. By forming dry drains of stone or other suitable material or by burning slipped material in situ. Often necessary to flatten slopes.

E. I. Have very few slips.

(j) *Where lines are laid on a clay subsoil what precautions do you take to prevent the clay working up through the ballast?*

M. R. A layer of slag, dust, granite dust or ashes is laid between clay and bottom ballast.

E. I. No experience.

III. — Ballast

(a) *What bottom ballast do you use?*

M. R. Slag or stone.

E. I. Stone.

(b) *Do you consider it best for your purpose or is no other available?*

E. I. Yes.

(c) *When stone is used what size do you specify?*

M. R. Stone to pass through a 9 inch ring but not a 3 inch ring.

E. I. Stone to pass through a 2 1/2 inches diameter ring in every direction.

(d) *What do you consider is a suitable depth of bottom ballast and do you vary*

this depth to suit varying conditions of sub-soil?

M. R. 8 to 9 inches.
E. I. 12 inches on main lines. Do not vary the depth.

(e) *Do you use the same ballast and the same depth of ballast on banks and in cuttings?*

M. R. Yes.
E. I. Yes.

(f) *What class and size of top ballast do you use and do you consider it the most suitable for your conditions of traffic?*

M. R. Broken slag ring, 2 1/2 to 1 1/2 inches. Broken slag ring, 3/4 to 1 1/2 inch. Granite chippings ring, 1/2 to 1 inch.
E. I. Same as bottom ballast.

(g) *Do you use special plant for laying, spreading and packing ballast and if so have you found it satisfactory and economical in use?*

M. R. No.
E. I. No.

(h) *Do you use special ballast on bridges carrying a sleeper road?*

M. R. Yes, granite chippings.
E. I. No.

(j) *If so, what minimum thickness of ballast do you allow between the bridge floor and the under side of sleepers?*

E. I. 2 feet on arched bridges; no ballast on girder bridges.

IV. — Sleepers.

(a) *What is the size of your standard sleepers?*

M. R. 9 feet and 8 ft. 6 in. × 10 inches × 5 inches.
E. I. The standard sleeper is a C. I. pot. Timber sleepers are 9 feet × 10 inch. × 5 inches.

(b) *Do you use special sleepers at the rail joints?*

M. R. 9 feet and 8 ft. 6 in. × 12 inches × 5 inches.
E. I. No.

(c) *Please give diagram showing how sleepers are spaced under the rails both for main and secondary lines.*

M. R.

For 100 lb. 45-foot rails.		*For 85 lb. 45-foot rails.*	
Joint.		Joint.	
ft.	in.	ft.	in.
1	0	0	11
2	3 1/2	2	4
2	5	2	5 1/2
13-2	7	13-2	7
2	5	2	5 1/2
2	3 1/2	2	4
1	0	0	11
Joint.		Joint.	

E. I. Various lengths of rails but spacing generally is 2 ft. 1 in. at joints and 2 ft. 8 1/2 in. to 2 ft. 10 in. at intermediate sleepers.

(d) *From what timber are they cut and what is the source of supply?*

M. R. Baltic redwood, also Oregon pine and British hardwood.
E. I. Sal deodar from India, jarrah from Australia, creosoted Douglas fir and Californian red wood from America, also some Burmese timber.

(e) *Have you used sleepers made of materials other than timber, if so with what results?*

M. R. Yes, steel sleepers tried without success.
E. I. Yes, cast iron sleepers and re-inforced concrete sleepers found satisfactory.

(f) *Do you specify that timber sleepers are to be seasoned before creosoting and what quantity of creosote do you require for each sleeper?*

M. R. Yes. Average. 2 3/4 gallons per 9 foot × 10 inch × 5 inch sleeper (Baltic red), 1 1/4 gallons per 8 ft. 6 in. × 10 inch × 5 inch sleeper (Oregon pine).

E. I. Douglas fir sleepers from America creosoted by empty cell and Rueping process.

(g) *Do you place sleepers in a vacuum to remove some of the creosote which has been injected?*

M. R. Yes.
E. I. No.

(h) *What is the average life of sleepers on your railway?*

E. I. Sal and Deodar 12 to 15 years, Jarrah wood, about 10 years. Creosoted Douglas fir, about 7 years in main line.

(i) *And do you consider that the increase of traffic has appreciably shortened this life?*

M. R. No, not appreciably.

(j) *Are all sleepers adzed under the chairs?*

M. R. No.
E. I. No.

(k) *Do you lay sleepers with the heart wood up or down?*

M. R. Up.
E. I. Down.

(l) *Have you made any experiments to justify your practice in this respect?*

. . . .

(m) *Is it your practice to remove occasional defective sleepers and replace them by new ones, or are all sleepers left in until relaying or general resleepering takes place?*

M. R. As a general rule sleepers are left in until relaying or re-sleepering is done. Occasionally defective sleepers are replaced where necessary.
E. I. Defective sleepers are replaced by best selected taken out during re-sleepering.

V. — **Rails.**

(a) *What is your standard rail for :*
1) *Main lines;*
2) *Secondary lines;*
3) *Branch lines?*

M. R. 1) 100 lb. — 2) and 3) 85 lb.
E. I. 1) 100 lb. (D. H.).
2) and 3) 75 lb. (D. H.).

(b) *Please give the length of rail used in each case and a cross section if this differs from the British standard section.*

M. R. 45 feet on passenger lines.
E. I. 1) 36 feet. — 2) 33 feet. — 3) 30 feet.

(c) *Have you found it necessary within recent years to use rails of greater weight owing to heavier engines and higher speed?*

M. R. Not within the past 15 years.
E. I. Yes, have introduced 100 lb. section rails for main lines.

(d) *What tests and chemical composition do you specify for rails? Give details where the British standard specification is not adopted?*

M. R. Falling weight, tensile, Brinell compression and abrasion tests are made. The chemical composition to show : carbon, 0.40 to 0.50; phosphorus, not to exceed 0.07; sulphur, not to exceed 0.06; manganese, not to exceed 1.10.
E. I. Falling weight on full length 85 lb. rails. Weight, 1 ton; bearings, 3 ft. 6 in. Drop, 25 feet. Maximum deflections : 1st blow, 2 3/4 inches; 2nd blow, 5 inches. Chemical analysis: carbon, 0.35 to 0.50; silicon, not to exceed 0.06; sulphur not to exceed 0.06; phosphorus, not to exceed 0.08; manganese not to exceed 0.80.

(e) *Do you use special steel for points and crossings. If so, what is the composition of it?*

M. R. Yes, steel with carbon content of 0.45 to 0.55.

E. I. Manganese steel crossings used but without success. Crossings made from high silicon steel rails which are satisfactory so far.

(f) *What loss of weight do you allow in rails before relaying takes place? What is the minimum weight of rails allowed in:*

1) *Main lines;* 2) *Secondary lines;* 3) *Branch lines.*

M. R. Varies according to local circumstances.
E. I. Relaying not governed by loss of weight.

(g) *Has heavier traffic necessitated the raising of this minimum weight?*

M. R. No.

(h) *Is relaying frequently necessitated by reasons other than loss of weight in rails for defects such as rails being dip jointed, chair galled, corrugated, battered,* i. e. *worn into hollows spread on top table.*

M. R. Yes, by flange cutting but not frequently for the other reasons.
E. I. Yes, odd rails occasionally from some such defects.

(j) *What steps, if any, do you take to preserve rails from corrosion in tunnels or elsewhere? Does economy result?*

M. R. By painting.
E. I. None.

(l) *What is the average life of rails on:*

1) *Main lines;* 2) *Secondary lines;* 3) *Branch lines.*

M. R. Approximately 12 to 18 years.
E. I. 1) 25 years. — 2) 30 years. — 3) 35 years.

(m) *What is the average number of broken rails found in the railway per annum, taken over the last 5 years, and what does this work out at per mile of single line.*

M. R. 6.6 per annum, 0.0025 per mile.
E. I. 30 per annum, 0.06 per mile.

(n) *Has the number of broken rails increased in recent years owing to heavier traffic?*

M. R. No.
E. I. No.

VI. — Chairs

(a) *What is the weight, size and shape of chairs used for the different sections of rails on your system? Please supply dimensioned sketch.*

M. R. For 100 lb. rails, 54 lb. each. Base area, 113 square inches. — For 85 lb. rails, 50 lb. each. Base area, 106 square inches.
E. I. For 100 lb. rails, 58 lb. each. Base area, 139 square inches. — For 75 lb. rails, 38 lb. each. Base area, 81 square inches.

(b) *Do you lay felt or other material between the chairs and sleeper?*

M. R. No.
E. I. No.

(c) *If so what benefit is derived from this practice?*

. . . .

(d) *Have you had to increase the size and weight of chairs owing to heavier traffic?*

M. R. Not since 1896.
E. I. Yes to suit increased axle load.

(e) *Are broken chairs more frequent than formerly?*

M. R. No.
E. I. No.

VII. — Chair fastenings.

(a) *Please give sketch shewing description of fastenings used and say whether you find them quite satisfactory for present day traffic?*

M. R. Two, three or four screws per chair (1 inch. diametre, 6 1/4 inches long

under heads) are now being used in hardwood sleepers.

E. I. Two 3/4 inch spikes per chair in timber sleepers.

(b) *Do the fastenings hold for the whole life of the sleeper or is it necessary to repair them by plugging the holes or moving the chairs to new positions?*

M. R. It is expected they will.
E. I. Yes.

(c) *If bolt or screw fastenings are used is it necessary to tighten these up at frequent intervals.*

M. R. No.
E. I. No.

(d) *If spike or treenail fastenings are used, do these need frequent attention?*

M. R. Occasionally.
E. I. No.

(e) *If Vignoles rails are used please give method of fastening and say whether and if so to what extent sole plates are used?*

E. I. Vignoles rails are used only on bridges and for points and crossings. Bearing plates are used on soft wood sleepers.

VIII. — Keys

(a) *If wooden keys are adopted, what wood do you find most satisfactory?*

M. R. Oak.
E. I. Babool and teak.

(b) *Is the wood treated in any special way or are the keys coated with black lead or with a preservative?*

M. R. No.
E. I. No.

(c) *Are keys compressed before use?*

M. R. No.
E. I. No.

(d) *What is the average life of wooden keys?*

M. R. 8 to 10 years.
E. I. About 8 years.

(e) *Is much work entailed in keeping keys in position in hot weather?*

M. R. Yes.
E. I. Yes.

(f) *Have you used with success, steel or other special keys, if so do you propose to adopt them more generally?*

M. R. Experimenting.
E. I. Yes, steel coil keys.

IX. — Fishplates

(a) *Please give dimensioned sketch shewing size and shape of fishplates with bolt holes.*

M. R. Plain fishplates 1 ft. 6 in. long and 1 1/8 inches thick with 4 holes for 7/8 inch bolts.
E. I. Deep fishplates: 1 ft. 6 in. long, 3/4 inch thick, 4 holes for 1 inch diameter bolts.

(b) *Has heavier traffic necessitated any recent alterations?*

E. I. No.

(c) *What class of steel do you specify for fishplates and bolts?*

M. R. Fishplates: Bessemer acid and open hearth acid. Bolts: open hearth acid steel.

(d) *Do you coat fishplates or bolts before use with oil, tar or paint?*

M. R. Fishplates: with Dr. Angus Smith's preparation. Fishbolts are oiled, the cavity in nuts filled with tallow.
E. I. Yes.

(e) *Have you any special rules as to the slacking of fishbolts in hot weather?*

M. R. No special rules. Instructions are issued.
E. I. Fishbolts are taken out and oiled twice a year.

(f) *Are the rail joints opposite to one another or are they « staggered »?*

M. R. Opposite.
E. I. Opposite.

(g) *Are you satisfied that your practice in this respect is better than the alternative. Have you tried both systems and if so what, in your opinion, are their relative merits and demerits ?*

M. R. Yes.
E. I. Yes. Staggered joints not found satisfactory.

X. — Expansion gaps.

(a) *What is your practice regarding the expansion gaps between rails ? In relaying do you lay to a fixed dimension or do you vary the gap to suit the temperature of the rail. If the latter, what rules are worked to by the platelayers ?*

M. R. Expansion gap varied according to the weather.
E. I. Gap varied according to temperature of the rail.

(b) *What is the maximum gap you allow and do you find it necessary to frequently adjust the rails ?*

M. R. 3/8 inch for 45 foot rails. Not frequently.
E. I. Occasionally necessary to adjust the rails.

(c) *Have you experienced trouble owing to expansion gaps closing up in hot weather and the track getting out of alignment ?*

M. R. Occasionally.
E. I. Seldom.

(d) *Have you trouble owing to closing of expansion gaps caused by creeping rails ? If so have you taken steps to prevent this and have they been effectual.*

M. R. Occasionally. Experimenting with steel keys.
E. I. Yes, battens under rails found efficient. Steel keys proved effective.

XI. — General lay out.

(a) *Have you many places on your line where speeds are limited ?*

M. R. Yes.
E. I. Yes.

(b) *Do you place indicators to show drivers where these reduced speeds apply ?*

M. R. No, except for temporary restriction.
E. I. Yes.

(c) *If so are these lit up at night ? Please send sketch.*

M. R. Yes, in cases as above.
E. I. Yes.

(d) *Are speed meters fitted to all or any engines ?*

E. I. No.

(e) *Is it your practice to limit speeds round curves where ample super-elevation can be given or do these limits only apply to places where crossings prevent the introduction of suitable cant or where there is an insufficient length of straight between reverse curves?*

M. R. Yes, in special cases.
E. I. No.

(f) *Have you taken steps to reduce the number of places where speeds are limited ?*

M. R. Yes.
E. I. Yes.

(g) *If so have you done this by flattening curves. Introducing transition curves. Putting in switch Diamonds, or by some other means.*

M. R. By flattening curves and by transition curves.
E. I. Transition curves exist at all curves.

(h) *Have you found that heavier traffic has made it more difficult to maintain the railway in good alignment ?*

M. R. Yes.
E. I. Yes.

(i) *Have you any system by which the regularity of curves is checked at regular intervals ?*

M. R. No, except in special cases.
E. I. Yes.

(j) *Have you fixed points on the railway from which the true position of the rails can be found by measurement ?*

M. R. Not generally.
E. I. Yes.

(k) *If so are these fixed points in the six foot or at the side of the line. How are they fixed?*

M. R. Substantial pegs at side of line.
E. I. At side of line posts made of old rails are fixed.

(l) *Has the use of a particular type of engine been found specially liable to cause deformation of the track or damage to the fastenings ? If so give particulars of this type of engine ?*

E. I. Yes, one type with 21 feet rigid wheel base on sharp curves.

[625 .14 (01]

APPENDIX 2.

Note on the question of the construction of the road bed and of the track,

By L. MARCZENI,
CHIEF CONSULTING CIVIL ENGINEER TO THE CZECHO-SLOVAKIAN MINISTRY OF RAILWAYS.

Figs. 1 to 14, pp. 114 to 118.

1. — Type of track.

The railway lines of the Czecho-Slovakian State carrying express passenger and fast goods traffic are all of the normal 1 435 m. (4 ft. 8 1/2 in.) gauge.

The maximum gradients and the minimum radius of the curves vary greatly according to the topographical conditions. The maximum gradient is in no case more than 15 per mil; the radius of the curves is rarely less than 250 m. (12 1/2 chains).

2. — Road-bed.

The normal dimensions of the road-bed for the double track are shown in figures 1 to 3.

3. — Ballast.

The normal profile of the ballast is shown above the normal section of the road-bed (figs. 1 to 3, double track).

On lines constructed for carrying heavy locomotives running at high speed, the ballast is almost invariably of broken stone; in some places the ballast consists of gravel, but this is rarely the case and it is being replaced by broken stone when the track is renewed. It is exceptional to use any other material for ballasting the main lines of railway.

The ballast of broken stone should consist of stones of uniform size; they should all pass through a ring 6 cm. (2 3/8 inches) diameter. Stones of larger size may only be used for the bottom layer of ballast on new lines on embankments liable to considerable settlement. The ballast must not contain more than one-third sand.

It is generally required that the ballast shall contain no earth or other matter in order that it may better stand the action of the weather and be sufficiently permeable to allow for drainage of water. Igneous rock is generally

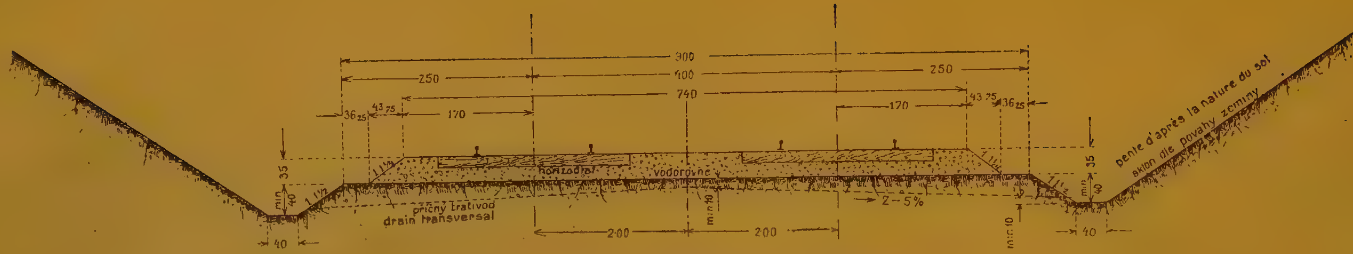


Fig. 1. — Normal section of track in cutting.

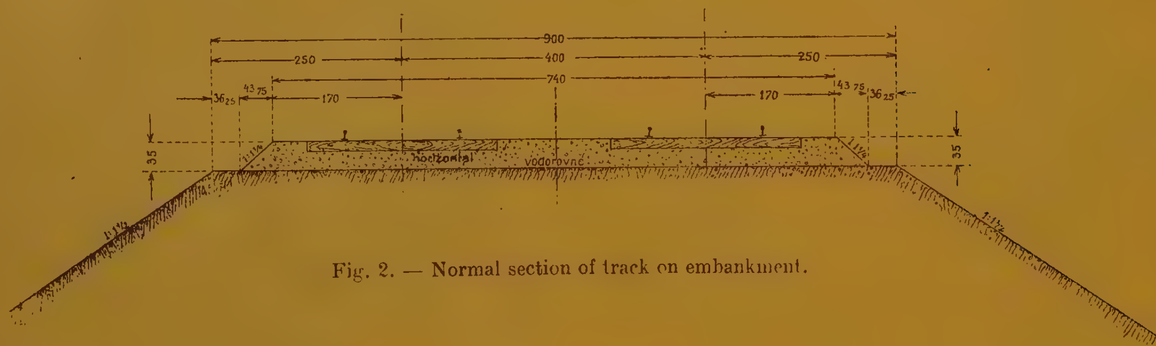


Fig. 2. — Normal section of track on embankment.

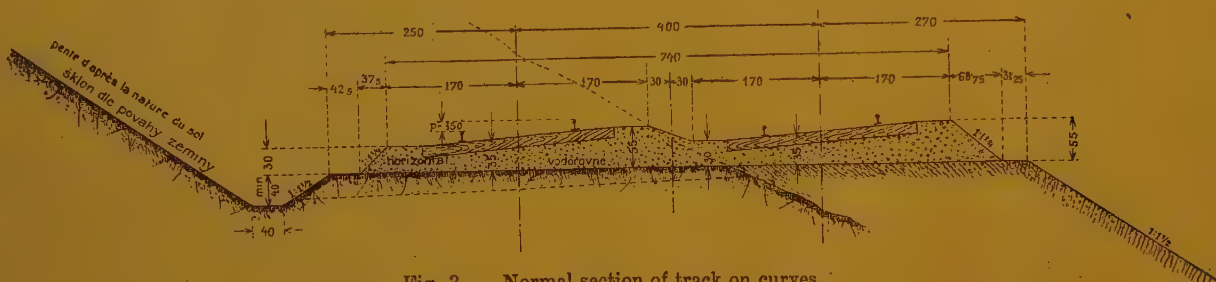


Fig. 3. — Normal section of track on curves.

Drawn for a superelevation of $p = 150$ mm. (5 15/16 in.)

Figs. 1 to 3. — Czecho-Slovakian State Railways. — Main lines. — Cross sections of double-track lines.

Note. — *On curves* the formation is widened on the outside thus : For superelevations of 30 to 80 mm. (1 3/16 to 3 3/16 inches), 10 cm. (3 15/16 inches); for superelevation exceeding 80 mm. (3 3/16 inches), 20 cm. (7 7/8 inches).

For superelevations of less than 30 mm. (1 3/16 inches) the formation is not widened. The increase of width of the formation proceeds progressively from the beginning of the transition curve.

Explanation of French terms : Drain transversal = Cross drain. — Pente d'après la nature du sol = Slope according to the nature of the ground.

used such as granite, porphyry, basalt, diorite, diabase (greenstone), syenite, clinkstone (a kind of felspar), etc.; ballast is also used of gneiss, compact limestone, various slates, conglomerates, etc.

Latterly no tests have been made to determine the resisting qualities of the ballast. Exception is made in the case of newly opened quarries, in which it is necessary to make tests to determine the quality of the stone. It has not been possible to make trials with a view to determining the most suitable thickness of the ballast.

4. Sleepers

On ordinary lines wood sleepers are used exclusively (oak, pine, larch, or beech) of the dimensions given in figure 9. Steel sleepers are only used for points and junctions.

With regard to composite sleepers trials have only recently been commenced on a small scale on light railways with reinforced concrete sleepers. The trials have not been in progress for sufficient time for any definite conclusion to be drawn.

Generally speaking, there is no adequate reason why the railway Administration should substitute sleepers of other materials for those of wood. Moreover no comparative tests have been made with this object.

Type A, used on main lines is shown in figures 4 to 8.

5. — Rails

On the most important Czecho-Slovakian railways Vignoles rails weighing 44.35 kgr. per m. (89.40 lb. per yard) are used throughout (type A).

The limit of wear permissible before the track is renewed, varies according to the line, according to the maximum load permitted per axle, and according to the maximum speed allowed. The maximum wear permitted is 20 mm. (0.79 in.) for speeds exceeding 60 km. (37 miles) per hour; generally the maximum wear must not exceed 10 mm. (0.39 in.).

The moment of inertia of new rails about the horizontal axis is 1 441.5 cm^4 (34.64 inches^4) and about the vertical axis 256.5 cm^4 (6.16 inches^4).

The normal length of rail rolled is 15 m. (49 ft. 3 in.), and each rail is drilled with three cylindrical bolt holes at each end.

The first hole is at 56.5 mm. (2 7/32 inches) from the end of the rail; the other two holes are drilled at distances respectively of 110 and 160 mm. (4 5/16 and 6 5/16 inches) from the first and from each other.

The supply and tests of the rails have been carried out up to the present according to the specification of the former Administration of the Austrian State railways. New specifications are being drawn and these will only be adopted after a series of trials have been made.

6. — Rail joints.

In the case of rails of type A, the cantilever joint as shown in figure 10 is used exclusively. The sleepers at the joint are placed 50 cm. (1 ft. 7 11/16 in.) apart, and the joints of both rails are opposite each other.

A double angle fish-plate weighs 17.18 kgr. (37.88 lb.); the total of the joint details for securing the rails weighs 39.69 kgr. (87.50 lb.) and the complete joint including the bearing plates and the holding-down devices weighs 59.81 kgr. (131.86 lb.).

The moment of inertia of a fish-plate about the horizontal axis is 545.4 cm^4 (13.10 inches^4); and that about the joint is 1 090.8 cm^4 (26.21 inches^4) as against 1 441.5 cm^4 (34.64 inches^4) for the standard rail itself.

In the case of other types of rail trials have been made of the cantilever joint and also of the bridge-joint of Professor Mašik; this joint has given good results, but has not yet been adopted to any great extent by reason of its cost. Trials have recently been made with another bridge joint designed by the engineer Mr. Pilař, and also with the bolt-less joints patented by Janoušek-Guba; it is not possible at present to give details of the results obtained.

7 — Methods of securing the rails to the sleepers.

The rails of type A are attached to the joint sleepers by means of sole-plates secured to the

Figs. 4 to 9. — Czecho-Slovakian State Railways. — Vignoles rails 15 m. (49 ft. 3 in.) long weighing 44.35 kgr. per m. (89.40 lb. per yard) (type A).

Diagram showing the plan of the sleepers and sole-plates for a 15 m. (49 ft. 3 in.) rail.

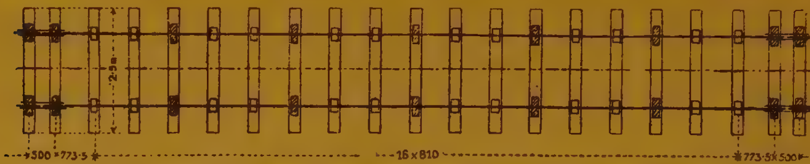


Fig. 4. — Type I, for straight lines and curves of over 600 m. (30 chains) radius on down-grades of 0 to 5 per mil (for speeds not exceeding 100 km. [62 miles] per hour). 19 sleepers (maximum distance apart 81 cm. [2 ft. 7 15/16 in.]). 24 wedge-shaped sole-plates; 14 holding-down plates.

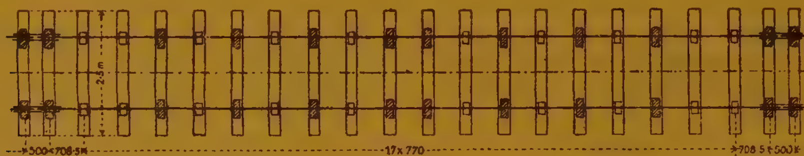


Fig. 5. — Type II, for the straight lines and curves of over 600 m. (30 chains) radius on down-grades of from 5 to 10 per mil, and for curves of a radius over 300 m, (15 chains) and up to 600 m. (30 chains radius on down grades of 0 to 5 per mil (for speeds not exceeding 100 km. [62 miles] per hour). 20 sleepers (maximum distance apart 77 cm. [2 ft. 6 5/16 in.]). 20 wedge-shaped sole-plates; 20 holding-down plates.

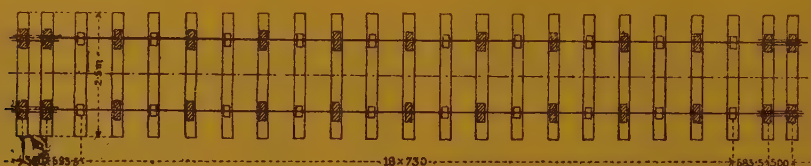


Fig. 6. — Type III, for the straight lines and curves of over 600 m. (30 chains) radius on down-grades steeper than 10 per mil, and on all curves up to 300 m. (15 chains) radius (for speeds not exceeding 100 km. [62 miles] per hour) and in future for speeds of 100 km. (62 miles) per hour. 21 sleepers (maximum distance apart 73 cm. [2 ft. 4 3/4 in.]). 20 wedge-shaped sole-plates; 22 holding-down plates.

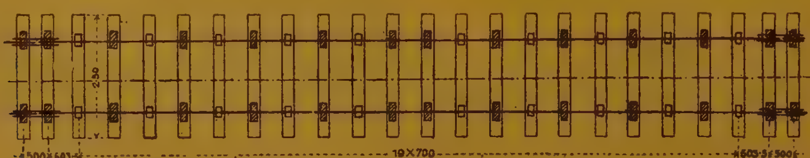


Fig. 7. — Type IV, for speeds of 105 and 110 km. (65 and 68 miles) per hour. 22 sleepers (maximum distance apart 70 cm. [2 ft. 3 9/16 in.]). 20 wedge-shaped sole-plates, 24 holding-down plates.

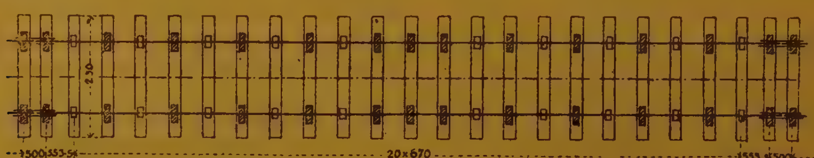
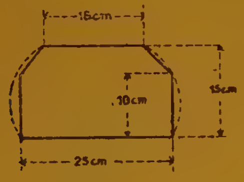


Fig. 8. — Type V, for speeds of over 110 km. (68 miles) per hour. 23 sleepers (maximum distance apart 67 cm. [2 ft. 2 3/8 in.]) and 20 wedge-shaped sole plates. 26 holding-down plates.

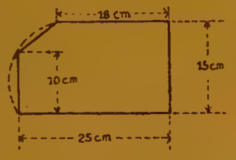
Note. — The wedge-shaped sole plates are indicated by an outlined rectangle ▯, the holding-down plates by a hatched rectangle ▨. — The same scheme for laying the track is used on the transition curves as on curves of constant radius with which the transition curves connect.

sleepers by holding-down plates, screw-spikes and octagonal dog-spikes (figs. 10 to 14).

The rails are also fixed in the same way to the intermediate sleepers, or are held by ordinary wedge-shaped sole-plates with screw-spikes (fig. 12). The one or the other of these two methods of securing the rails is used according to the maximum speed allowed on the line, and according to the curves and gradients (see figs. 4 to 8).

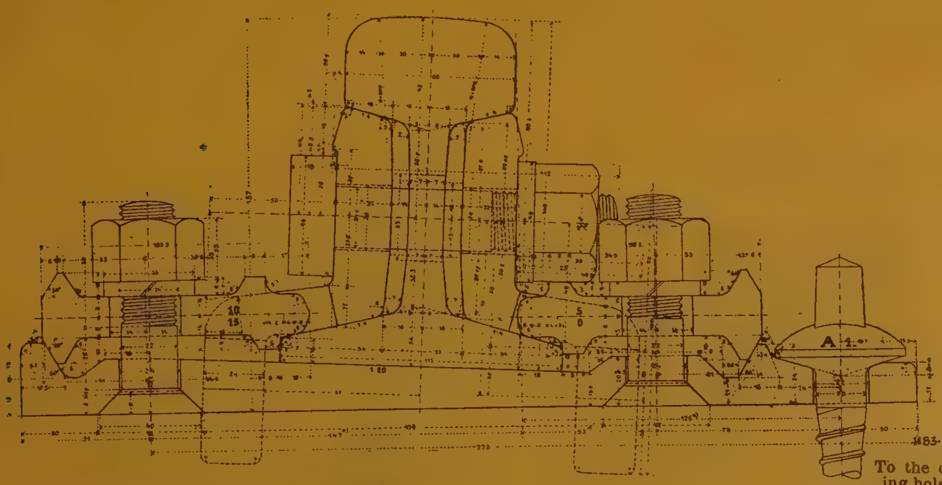


Type II.



Type II *a*. — Used only for intermediate sleepers and less than one-tenth of the total in number.

Fig. 9. — Type and dimensions of wooden sleepers length 2.50 m. (8 ft. 2 1/2 in.)



*) Varying according to gauge.

Fig. 10. — Czecho-Slovakian State railways.
Vignoles rails 15 m. (49 ft. 3 in.) long, weighing 44.35 kgr. per m. (89.40 lb. per yard) (type A). Section.

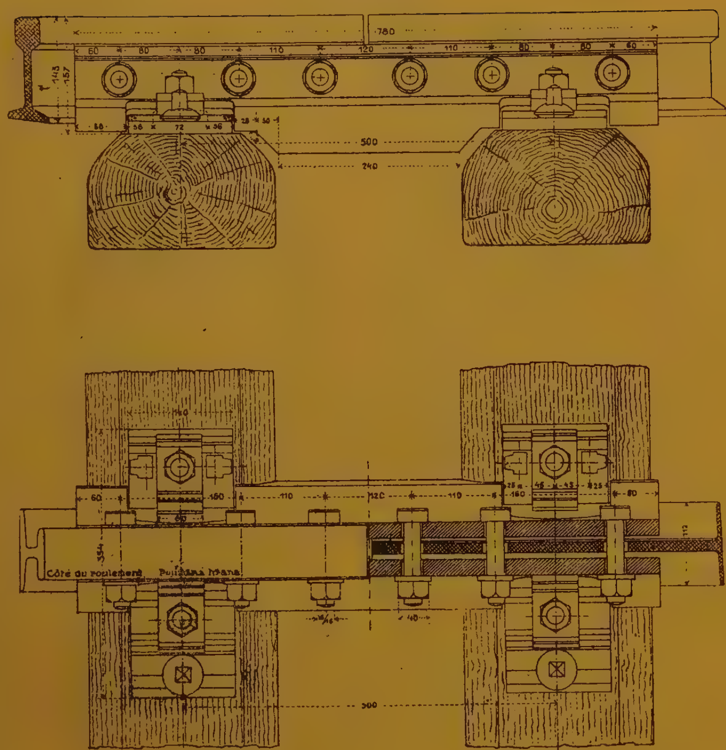
On bridges the rails are secured as on the ordinary track. The form of construction is departed from only at level crossings, over places where cross-ditches have to be dug, and at insulated rail joints; in these cases special sole-plates and screw-spikes are used.

8. — Track.

For calculating the superelevation of the outer rail on curves the formulæ given below are used, in which :

p represents the superelevation of the outer rails in millimetres;

Side elevation.



Plan. *Horizontal section.*

Fig. 11. — Rail-joint.

Explanation of French terms : Côté du roulement = Running edge.

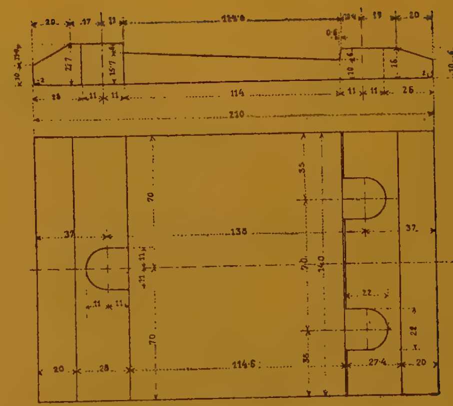


Fig. 12. — Wedge-shaped sole-plate.

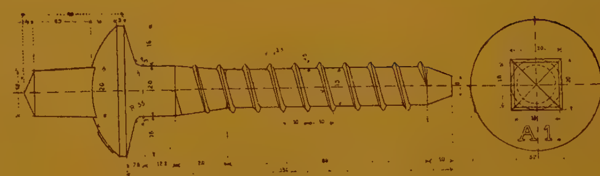


Fig. 13. — Screw-spike.

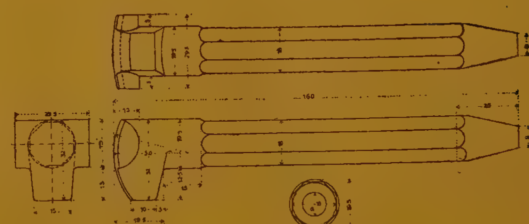


Fig. 14. — Octagonal dog-spike for holding-down plates.

Figs. 11 to 14. — Czecho-Slovakian State Railways. — Vignoles rails 15 m. (49 ft. 3 in.) long weighing 44.35 kgr. per m. (89.40 lb. per yard) (type A).

V represents the maximum speed allowed in kilometres per hour.

R represents the radius of the curve in metres.

On the open track the superelevation is that calculated as follows :

a) when

$V < 1.971\sqrt{R}$, according to the formula :

$$p = 11.8\frac{V^2}{R} \text{ (up to 45.836 mm.)} \quad \text{and}$$

b) when

$V > 1.971\sqrt{R}$, according to the formula :

$$p = 46.514\frac{V}{\sqrt{R}} - 45.836$$

On lines carrying very heavy goods traffic and not having heavy passenger traffic, the superelevation given on tracks in the stations and on the open road between stations and block signals is the minimum, which is calculated :

a) when

$V < 1.31\sqrt{R}$, according to the formula :

$$p = 11.8\frac{V^2}{R} \text{ (up to 20.263 mm.)} \quad \text{and}$$

b) when

$V > 1.31\sqrt{R}$, according to the formula :

$$p = 30.926\frac{V}{\sqrt{R}} - 20.263$$

The tables prepared by the former Austrian State railways by calculation from these formulæ are still in use.

The greatest normal maximum superelevation amounts to 142 mm. (5 5/8) inches) and the greatest normal minimum superelevation is 106 mm. (4 3/16 inches). Superelevation of less than 6 mm. (1/4 inches) is not given.

The widening of the gauge is determined thus :

On curves of a radius :	up to 349 m. (17.4 chains), an amount equal to 30 mm. (1 3/16 inches).									
	from	350 to	399 m. (from	17.5 to 19.9 chains),	an amount	equal	to	28	mm.	(1 1/8 inches).
	—	400 to	499 m. (—	20.0 to 24.9	—),	—	—	24	—	(15/16 inch).
	—	500 to	599 m. (—	25.0 to 29.9	—),	—	—	20	—	(25/32 —).
	—	600 to	699 m. (—	30.0 to 34.9	—),	—	—	16	—	(5/8 —).
	—	700 to	999 m. (—	35.0 to 49.9	—),	—	—	12	—	(15/32 —)
	—	1 000 to	1 499 m. (—	50.0 to 74.9	—),	—	—	8	—	(5/16 —).
	—	1 500 to	1 999 m. (—	75.0 to 99.9	—),	—	—	4	—	(5/32 —).

In cases where sole-plates are used for securing the rail the widening of the gauge is as follows :

On curves of a radius :	up to 373 m. (18.6 chains), an amont equal to 30 mm. (1 3/16 inches).									
	from	375 to	499 m. (from	18.7 to 24.9 chains),	an amount	equal	to	25	mm.	(1 inch).
	—	500 to	599 m. (—	25.0 to 29.9	—),	—	—	20	—	(25/32 —).
	—	600 to	799 m. (—	30.0 to 39.9	—),	—	—	15	—	(19/32 —).
	—	800 to	1 499 m. (—	40.0 to 74.9	—),	—	—	10	—	(13/32 —).
	—	1 500 to	1 999 m. (—	75.0 to 99.9	—),	—	—	5	—	(3/16 —).

The required superelevation is obtained by a gradient of 1 in 500 leading up to the full superelevation in the case of speeds exceeding 60 km. (37 miles) per hour, and an inclination of 1 in 300 for slower speeds. The inclination of 1 in 300 is used in exceptional cases when it is a question of rather higher speeds up to 80 km. (50 miles) per hour.

These superelevation gradients are arranged on the transition curves and transition curves are usual on all lines carrying heavy traffic.

The maximum length of straight between reverse curves is :

10 m. (32 ft. 10 in.)	for speeds up to	50 km. (31 miles)	per hour.
30 m. (98 ft. 6 in.)	— —	60 — (37 —)	—
40 m. (131 ft. 6 in.)	— —	70 — (44 —)	—
50 m. (164 ft. 4 in.)	— —	80 — (50 —)	—
60 m. (197 feet)	— —	90 — (56 —)	—
100 m. (328 feet)	— —	100 — (62 —)	—

and upwards, measured between the ends of the transition curves.

The insertion of a length of short straight between two curves having the same direction is considered disadvantageous; and for this reason is very rarely adopted. No minimum length of straight is specified. When, however, it is less than 20 m. (65 ft. 8 in.) it is given a superelevation and a widening of the gauge equal, to one-third in each case, or those given for the adjacent curve of smaller radius.

In consequence of the proposed increase of speed, it will be necessary to increase the number of sleepers for each 15 m. (49 ft. 3 in.) rail. A new arrangement has been prepared in view of this.

It is also intended to increase the thickness of the ballast up to 35 cm. (1 ft. 1 3/4 in.) and even 45 cm. (1 ft. 5 3/4 in.). These measures will be adequate for speeds not exceeding 90 km. (56 miles) per hour; above this speed it will be necessary to consider the strengthening of other details of the track.

As regards the open track, increase of speed involves increase in the minimum radius of the curves, in the minimum length of straight between curves and in the superelevation of the outer rail above that determined by the old rules.

Apart from a reduction in the cost of maintenance, obtained by the general strengthening of the track, by increasing the weight of the rails, and of all the details of the track, it has been possible to effect a still further reduction in particular by the use of the sole-plates for securing the rails as has been mentioned above.

The widening of the gauge specified for curves is obtained by change of position in the holding-down plates. This method avoids modification in the method of securing the rail and of adzing the shoe-seat on the sleeper and it increases the life of the sleepers appreciably.

The holding-down plates just mentioned have the further advantage of preventing, to a great extent, creeping of the rails. This trouble is fairly frequent on our lines owing to the unfavourable conditions caused by the gradients. The use of holding-down plates renders unnecessary the general use of other methods for preventing the creeping of the rails.

Creeping of rails can be stopped, moreover, by cutting gaps in the horizontal flanges of the angle fish-plates which enable them to bear on the sole-plates and against the holding-down plates and this is helped by the vertical bearing surfaces of the double angle fish-plates as the latter bear against the sleeper when creeping of the rails begins to take place.

In this connexion it is necessary to note the importance of good ballast of broken stones.

Amongst the various precautions taken against the creeping of rails there should also be mentioned the trials that have been made on our lines of various clips of the Rambacher, Neumann, Lukesch and Liemann-Petzold systems; there are in addition the Guba wood blocks for tightening the rails, the Dorfmuller wedges or keys, the Vogel friction screw, the Paral bearing plates, lengthened sole-plates, angle check-plates, angle bearing-plates, etc. As the results obtained by these devices have not been generally satisfactory, or have not been commensurate with the cost, they have been abandoned.

The distortion of the track due to the passage of express trains has not yet formed the subject of special investigation. It has, however, been found that unfavourable symptoms have followed the use of the type E (0-5-0) goods locomotives with tenders [having a wheel base of 5.60 m. (18 ft. 4 1/2 in.) and axle

loads from 13.1 to 14.1 metric tons], and running at a speed of 50 km. (31 miles) per hour; these phenomena have been particularly marked in cases where these locomotives have been run light and tender first. These locomotives have a bad effect on the track; they soon increase the widening of the gauge beyond the permissible limit and they are also frequently the cause of considerable radial distortion of the track on curves and particularly on transition curves; this is moreover often accompanied by fracture of the fish-plates as well as by hammering of the sole-plates into the sleepers.

9. — Running through stations.

As far as possible no limit is fixed for the speed of trains in running through the stations. With this object in view the main line tracks are of the same construction in stations as on the open track.

When a reduction of speed is required by local conditions, a lighter form of track construction of type X^a, is adopted for the station length. This form of construction is also used on the auxiliary tracks in stations, as well as on the open track for secondary or light railways carrying lighter traffic.

The rails of a track of type X^a, weigh 35.65 kgr. per m. (71.87 lb. per yard). The total permissible amount of wear is 14 mm. (0.55 inch); when, however, the speed exceeds 40 km. (25 miles) per hour the wear is not allowed to exceed 11 mm. (0.43 inch); for speeds over 60 km. (37 miles) per hour wear exceeding 8 mm. (0.32 inch) is not generally allowed.

The moment of inertia of the rails, when new, about the horizontal axis is 925 cm^4. (22.23 $inches^4$); and about the vertical axis it is 178 cm^4 (4.28 $inches^4$).

The rails are rolled to a normal length of 15 m. (49 ft. 3 in.) and are drilled with three bolt-holes at each end; the first hole is placed at 49 mm. (1 31/32 inches) from the end of the rail; and the other holes are drilled at 125 mm. (4 15/16 inches) pitch.

This is also a cantilever joint with a distance between sleepers of 48 cm. (1 ft. 6 15/16 in.).

With regard to points and crossings, type A with steel sleepers is used for main-line fast traffic tracks in stations.

These points have flexible tongues and can be run over at speeds up to 90 km. (56 miles) per hour. Only single points and double-slip points are constructed of this type.

For other points, for auxiliary tracks and for main lines of less importance, points and crossings of the type X^a are used. In this system the points have the tongues arranged with heel pivoted tongues; they are laid on steel sleepers when they carry express traffic; in ordinary cases they are carried on wooden sleepers.

In the latter case cast-steel crossings are used; when the points are carried on steel sleepers, as well as in those of type A, the point of crossing alone is of cast steel and the wing-rails are of the normal section. By this system the number of joints at the crossing is reduced.

Crossings of type X^a with wooden sleepers (for the present axle loads) are capable of carrying traffic at a speed of 60 km. (37 miles) per hour, and those with steel sleepers a speed of 80 km. (50 miles) per hour; crossings of type A will carry traffic at 90 km. (56 miles) per hour. For higher speeds and increased axle loads it will be necessary to adopt points still stronger than the existing ones of type A; it will ultimately be necessary to use materials of greater strength for their construction; the designs for these have not yet been completed.

Track of type X^a allows of a speed of 90 km. (56 miles) per hour for the present axle-load of 14.7 metric tons; for higher speeds track of the type A described above is used, and is being introduced on lines having slower traffic in view of the proposed increase in axle-load.

The present track is, in the majority of cases, adequate for an increased speed, particularly as the axle-loading will not be increased simultaneously and that there is no question of speeds above 90 km. (56 miles) per hour. Now, generally speaking, the limits are fixed by the worst curves on different

lines, and these conditions will require modification when the lines have been constructed properly.

10. — Locomotives and rolling stock.

. . . .

11. — Speed of trains.

On the chief and best maintained lines a maximum speed is allowed to-day, of 90 km. (56 miles) per hour a speed which, however, is only attained by passenger trains. Goods trains do not usually exceed a speed of 45 km. (28 miles) per hour.

The speed of 90 km. (56 miles) per hour is allowed on the straight and on curves of not less than 500 m. (25 chains) radius.

For curves of smaller radius the maximum speeds are as follows :

For a radius	of 450 m.	(22.5 chains),	a speed of	85 km.	(53 miles)	per hour.
—	—	of 400 m.	(20.0 —),	—	80 —	(50 —)	—
—	—	of 350 m.	(17.5 —),		75 —	(47 —)	—
—	—	of 300 m.	(15.0 —),	—	70 —	(44 —)	—
—	—	of 280 m.	(14.0 —),	—	65 —	(40 —)	—
—	—	of 240 m.	(12.0 —),	—	60 —	(37 —)	—
—	—	of 200 m.	(10.0 —),	—	55 —	(34 —)	—
—	—	of 180 m.	(9.0 —),	—	50 —	(31 —)	—
—	—	of 150 m.	(7.5 —),	—	45 —	(28 —)	—

It is intended in the future to allow :

A speed	of 95 km.	(59 miles)	per hour	on curves	having a radius	not less than	600 m.	(30 chains).
—	of 100 —	(62 —)	—	—	—	—	700 m.	(35 —).
—	of 105 —	(65 —)	—	—	—	—	800 m.	(40 —).
—	of 110 —	(68 —)	—	—	—	—	900 m.	(45 —).
—	of 115 —	(71 —)	—	—	—	—	1 000 m.	(50 —).

The maximum speed of 90 km. (56 miles) per hour may be attained on down-grades not exceeding 11 per mil. On steeper gradients it is necessary to reduce the speed proportionately; for trains fitted with continuous brakes the permissible speeds are :

On a gradient	of 12	per mil,	a speed of	85 km.	(53 miles)	per hour.
—	of 16	—	—	70 —	(44 —)	—
—	of 20	—	—	75 —	(47 —)	—
—	of 22	—	—	70 —	(44 —)	—
—	of 25	—	—	60 —	(37 —)	—
—	of 30	—	—	50 —	(31 —)	—
—	of 35	—	—	45 —	(28 —)	—
—	of 40	—	—	40 —	(25 —)	—

It is proposed to allow in future :

A speed	of 95 km.	(59 miles)	per hour	on down grades	exceeding	10	per mil.
—	of 100 km.	(62 —)	—	—	—	7	—
—	of 105 km.	(65 —)	—	—	—	5	—
—	of 110 km.	(68 —)	—	—	—	2	—

For running through junctions in stations or on the open track the following rules apply :

With trailing points on the straight all trains may run at the speed allowed on the open track, provided that the construction of the points permits of this :

With facing points which are locked, express passenger and mail trains may run at a speed of 60 km. (37 miles) per hour. This speed may be increased to 80 km. (50 miles) per hour in the case of single points of type X^a with steel sleepers. Under the same conditions points of type A may be run over at a speed of 90 km. (56 miles) per hour. More stringent regulations are in force for the maintenance and replacement of points that are run over at high speeds.

Express passenger and mail trains must not run over facing points, that are not locked, at a speed exceeding 40 km. (25 miles) per hour.

Goods trains must not run over facing points on the straight at a speed exceeding 20 km. (12 miles) per hour.

On curves all trains may take trailing points at a speed not exceeding 30 km. (19 miles) per hour; with facing points the speed for passenger and mail trains is 30 km. per hour; and for goods trains 10 km. (6.2 miles) per hour.

With regard to the reasons that have determined the speeds mentioned above, it is to be noted that :

The limit of 90 km. (56 miles) per hour for the speed on the open track was already in force on the railway system taken over from the old Austro-Hungarian State railways; the track of these railways had been constructed for this speed. After the dismemberment of Austria-Hungary it was decided to gradually increase the speed of the trains above this limit on the main lines for the express trains of the Czecho-Slovakian State railways, and the necessary constructional work has been put in progress since 1919, both with regard to the modification of the curves and also of the track.

The limits for speed on the various curves have been determined in such manner that the normal superelevation, calculated from the formulæ, quoted above, will in no case appreciably exceed 140 mm. (5 1/2 inches). In order to determine the greatest permissible speeds on the various down-grades the distance of 700 m. (766 yards), protected by the signal, was taken as the length within which the train must be capable of being brought to rest, even though travelling at the maximum speed. In determining the speed of taking the points account was taken of the strength of the rails and of the tongues of the points, their general arrangement, the radius of curvature when the track is on a curve, etc.

The fastest trains on the Czecho-Slovakian State railways run about equally on single tracks and on double tracks.

[625 .14 (01 & 625 .141]

APPENDIX 3.

Notes on testing ballast by professor K. Špaček's method,

By H. DEYL,
ENGINEER,
ADVISORY SUPERINTENDENT OF RAILWAY CONSTRUCTION ON THE CZECHO-SLOVAKIAN RAILWAYS.

Fig. 1, p. 125.

As a result of the discussion that took place in Rome relating to question I (Construction of the road bed and of the track), we think we can recommend a mode of testing the ballast devised by Mr. K. Špaček, professor at the Institute of Roads and Railways at the Czech Technical School at Prague.

This method consists in submitting the ballast to the following tests :

1° *Impact test*, by means of a special apparatus (see appendix);

2° *Determination of the density* of the stone, after drying for three hours (the temperature of the stone being 50° C.) (122° F.);

3° *Hygrometric test.* — The stone is immersed in water and the increase in weight is measured;

4° *Freezing test.* — The stone after soaking in water is subjected to twenty-five successive freezings and thawings in order to ascertain its power of resisting frost;

5° *Abrasion test performed on the Bauschinger or the Deval machines*;

6° And finally the stone is subjected to petrographical examination in order to determine the characteristics of the rock.

The following is a copy of the test certificate.

APPENDIX.

INSTITUTE OF ROADS, RAILWAYS AND UNDERGROUND WORKS,
of the Higher Czech Technical School, Prague.

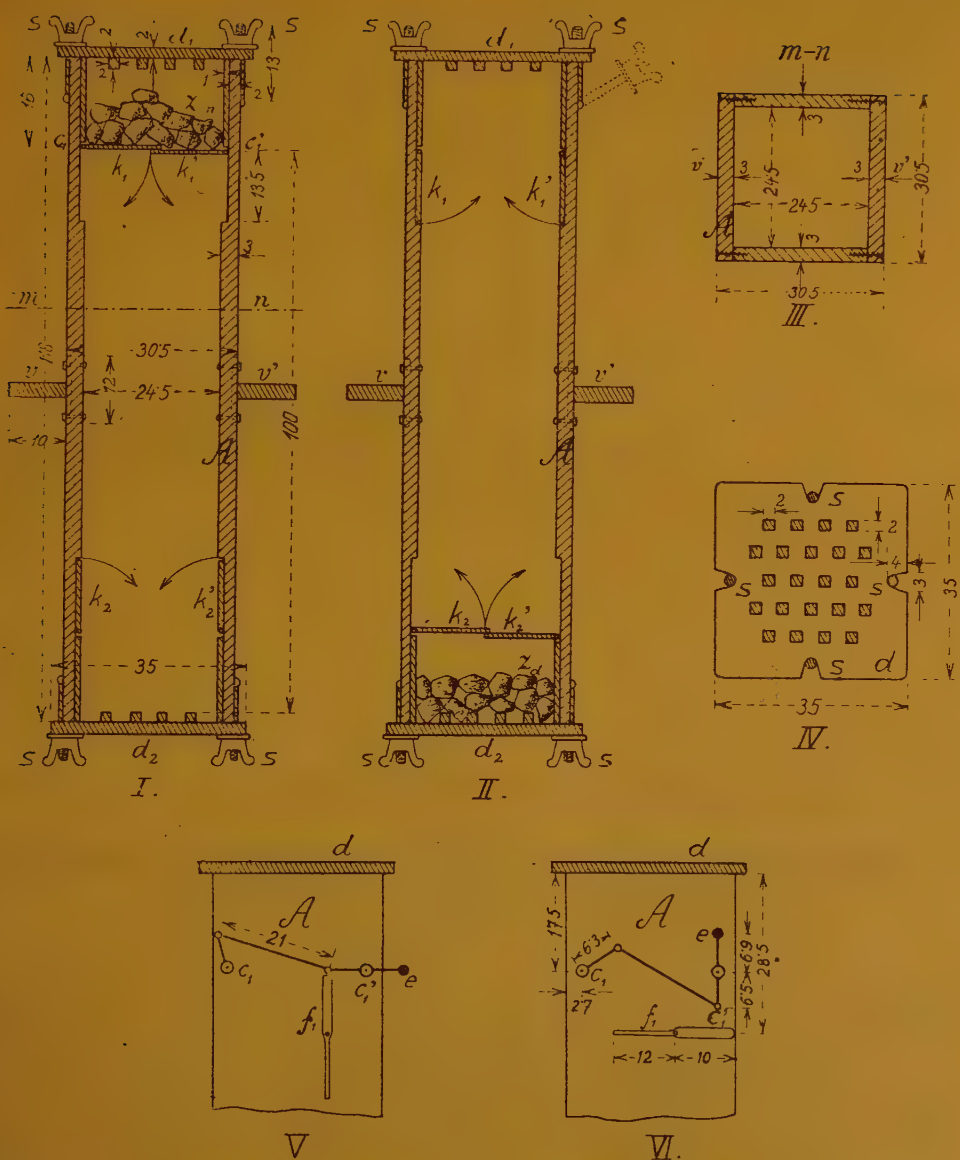
Professor K. ŠPAČEK, engineer.

Certificate No. ....

Test of ballast ...., *received at the Institute the* ....

Address :
Praha, Karlovo náměstí č. 288-II.,
« U Sedlerů », II. patro.
Telefon čís. 3034 (Techn. vys. škola).

Test sample.			Certificate.
Test No.	Weight in gr.	Date received	Date certificate dispatched..........



The flaps k_1, k'_1 in the position I.

The flaps k_1, k'_1 in the position II.

Fig. 1. — Diagrammatic view of apparatus.

Test number ....

Description of rock ....

Place of origin ....

....

Features (colour, character of surface and angles, etc.) ....

....

Particulars of test.

1. *Impact test* ....

Weight of sample .... *gr.* *Number of pieces in sample* ..

Number of reversals.	Pieces remaining on a sieve of .... meshes						Dust.	Fragments less than 10 mm., (columns 6, 7, 8).	Total number of fragments.	Weight per 2 500 gr.	*Remarks* (small fragments, etc. shown in columns 6, 7 and 8 are not put through the machine again.)
	$r =$ 20 mm.		$r =$ 10 mm.		$r =$ 1.6 mm	small.					
	Number.	Weight *g*.	Number.	Total weight in grammes of fragments under each heading.							
1	2	3	4	5	6	7	8	9	10	11	12
10											
30											
60											
100											
150											
200											

Summary.

Condition	Number of pieces in the sample.		Division effected in course of test by 75 kgr.-m. on the basis of 2 500 gr.	*Remarks.*
			Number of reversals.	
at the commencement.				
	increased to			
after....... reversals.				
	diameter :		Average	
blows.	over 20 mm.	from 10 to 20 mm.	.... gr. per 75 kgr.-m.	19—

See graphical diagram attached hereto.

2. *Density after drying for three hours at + 50° C. (122° F.).*

Density = weight in gr. divided by volume in cm³ = ...

3. *Hygrometric test. — The stone is saturated with water by being plunged into water and left covered for six hours :*

The amount of water absorbed is measured by the difference between the weight of the thoroughly wetted stone and that of the dry stone, in gr. ....

4. *Freezing test. — The stone after soaking in water is frozen and thawed twenty-five times in order to determine its power of resisting frost* ....

5. *Abrasion test effected on the Bauschinger grinder or the Deval machine. — Under a pressure of* .... *kgr. per cm², and using a grindstone* .... *m. in diameter, an amount of* .... *cm² has been removed from the test piece, or* .... *cm³* (.................... *gr.*).

Consumption of electric power .... W.
Less amount consumed in running light .... »

Net amount used per .... *cm³* .... W.

That is, per cm³ .... W.

6. *Characteristics of the rock. (Petrographical examination)* ....

Certificate.

I certify that the ballast ....

is of .... *quality*

Institute of Roads, Railways and Underground Works of the Higher Czech Technical School at Prague.

...................., *the* ....

The quality is given as : Excellent, very good, good, average, adequate, poor or bad.

[625 .17]

QUESTION II

MAINTENANCE AND SUPERVISION OF THE TRACK.

Measures to be taken to provide an economic organization for the maintenance and the supervision of the track, taking into consideration the increase of traffic and speed as well as the rise in wages and in the cost of materials.. Use of mechanical appliances. Results obtained.

Preliminary documents.

1[st] report (America), by Mr. E. RANDOLPH. (See English edition of the *Bulletin* of October 1920, p. 665, or separate issue [with red cover] No. 9.)

2[nd] report (Great Britain), by Mr. Chas. J. BROWN. (See English edition of the *Bulletin* of June 1921, p. 663, or separate issue [with red cover] No. 18.)

3[rd] report (America), by Mr. E. STIMSON. (See English edition of the *Bulletin* of August 1921, p. 977, or separate issue [with red cover] No. 23.)

4[th] report (all countries, except Great Britain and America), by Mr. J. BARBIERI. (See English edition of the *Bulletin* of January 1922, p. 139, or separate issue [with red cover] No. 54.)

Special reporter : Mr. E. STIMSON. (See the *Bulletin* for April 1922, p. 631.)

SECTIONAL DISCUSSION

Meeting held on 20 April 1922 (morning).

Mr. BRUNEEL, IN THE CHAIR.

The President. — We will proceed with the discussion on question II.

Mr. Brown, *reporter,* reads the special report [1] — prepared by Mr. Stimson — giving a summary of the four reports on this question.

This reading receives the unanimous applause of the assembly.

The President. (In French.) — It may be said that the report, which has just been read to us, is a very complete treatise on the subject, rather than a resume. It appears to me impossible to consider this report seriatim, and I think we are unanimous in considering that we should restrict ourselves at the present time to a few items of special importance. Moreover, it is the fourth occasion since 1885 that the question of the inspection

(1) The special report was published in No. 4, April 1922 of the *Bulletin.*

and maintenance of the permanent way has been discussed by the Congress.

It seems to me that it is advisable today to examine chiefly the means employed to reduce expenses, to which we were not obliged to give so much attention before the war, when there was not the same necessity, as there is today, to take into account the curtailment of the working day or the considerable increase in wages.

In the report which has just been read, there is a very interesting portion to which we may confine our attention, namely, that which deals with the general organisation of the permanent way inspection and maintenance staff.

I propose therefore to proceed at once to the question of the organisation of the maintenance gangs.

This question, on which I submitted a report at the St. Petersburg Congress, was discussed at length at that session, and a definite conclusion was arrived at as regards the organisation of the maintenance gangs.

I would, however, draw attention to the fact that the figures given for the present day differ slightly from those quoted at St. Petersburg and Berne. As regards the organisation of the maintenance gangs and the extent of their lengths, a somewhat novel scheme is put forward. It is to combine several small lengths into one large section so as to effect a reduction in the number of men, which will vary in accordance with the amount of maintenance necessary.

In Belgium, our gangs are as a rule arranged on the basis of one man to every 0.62 to 1.86 miles, according to the importance of the lines. On lines carrying heavy high speed traffic, we allow one man per 0.62 miles. On lines with a very light traffic, we allow one man for 1.86 miles. The strength of the gangs is as a rule from four to six men. The question as it stands today is whether it is not beneficial to combine three or four small gangs into one large gang, but to do this it is essential to provide the men with means of rapid transport.

Our colleagues may be able to inform us whether this system has already been put into force on their railways.

Mr. Tettelin, French Nord Railway. (In French.) — We employ on the Nord Railway a certain number of « draisines » driven by petrol motors. By means of these « draisines » we can arrange for a rapid distribution of the maintenance staff in accordance with a prearranged programme.

The system consists of transporting by means of these « draisines », flying gangs which travel about the line and carry out repairs over its entire length. After this, the line is left to itself. It is obvious that the number of men should be numerically proportional to the length of the line. The result of the system is to dispense with the local maintenance gangs.

This method of organisation is being tried on branch lines, but we have not yet definitely adopted it.

Mr. Henry, French Est Railway. (In French.) — It is in operation on the majority of the French railways.

Mr. Quinquet, Paris-Lyons-Mediterranean Railway. (In French). — The « draisines » which we use on our system dont run as service trains, which can only be directed on sidings at the stations. A « draisine » which can be lifted off the rails wherever the gang has work to perform is much preferable, since it will save a large amount of time, and consequently money. The driver of the « draisine », instead of wasting his time in taking the « draisine » to a station

and then returning on foot to the place where the gang is working, commences to work with the platelayers, which he has transported, as soon as they start work.

We have made experiments with a draisine provided with a portable telephone. These tests have been made under the supervision of representatives of the Permanent Way and Traffic Departments, and have been with the object of determining whether the advantages gained by one department do not give rise to disadvantages from the point of view of the other department. The portable telephone on the draisine communicates with the station over the ordinary wires. When it is required to occupy the line, permission is asked of the station. If this is given, the draisine starts away, and when it has reached the place where the gang has work to perform, it is lifted off the rails and the ganger telephones « I have cleared the line ».

When it is required again to put the « draisine » on the line, the ganger telephones to know if everything is clear.

The report of the trials carried out to test the principles under which the « draisine » is used is favourable. It states, however, that the « draisine » used is not powerful enough to carry sufficient load on the steep gradients. This is a defect which can obviously be remedied by increasing its power.

The trials were mainly carried out in order to ascertain whether « draisines » provided with telephones might be used to carry men and distribute them along the line without interfering with the running of the trains. From this point of view, the trials have been conclusive.

At the present time, we are trying to obtain a type of « draisine » suitable, not only for carrying men, but also for material.

We hope that by such means one gang may be able to maintain 9 to 11 miles of line.

Mr. Jullien, Paris-Orleans Railway. (In French.) — We have made similar trials on the branch line from Blois to Villefranche-sur-Cher. This line, which is 33.6 miles in length is divised into four lengths for inspection purposes, and into two lengths for maintenance. On each of the latter a « draisine » is used to transport men and materials.

The system differs from that mentioned by Mr. Quinquet, in that we have established between stations a number of sidings for the « draisine », which are provided with telephones, so that the adjoining stations can be informed when the line is clear, and by which means permission may be obtained when it is desired to use the « draisine ».

This arrangement works to our complete satisfaction, and up to the present has resulted in a yearly saving of about 1 400 fr. per km.

I have the honour to lay on the table a note giving full particulars of this arrangement. (See appendix 1.)

The President. (In French.) — I propose that we now proceed to the discussion of a question which is also somewhat of a new departure, namely, that of permanent way maintenance by private contractors.

This method is not used in Belgium. We have made our minds almost as a matter of course, against the idea of employing private firms for permanent way maintenance work. I should be glad if our colleagues would give us any information on the results of experiments of this nature.

Mr. Henry. (In French.) — On the French Est system, for some years past, we have employed contractors for certain work in connection with track mainte-

nance in cases where it has been specially difficult to obtain labour.

When this system was first instituted, we employed some contractors who were unequal to the task. We had accepted the first which offered to undertake the work, but when they recognised that they were unable to fulfil the conditions which were laid down, they gave up the job as they were unable to obtain the price that they required.

We are at present employing three or four contractors whom can trust and who give us satisfaction.

We do not accept the lowest tender. We submit a specification to the contractors, and we rule out those who do not appear to us to be able to carry out these conditions. I should add that the difficult work of lifting and slewing the track is done by the company's employees.

M. Quinquet. (In French.) — We have a contract which is very satisfactory for relaying work. We have tried a contract system for maintenance work, but have had to abandon it, partly because the price of the necessary plant is too great, and also because it is difficult to pack a loose sleeper by means of mechanical tools without disturbing the neighbouring sleepers.

We have obtained very good results with the « Collet » system for relaying. Generally speaking we may say that packing sleepers by mechanical means forms a bed of ballast under the sleeper which is more highly compressed at the base, but less compressed in the upper layers, than would be obtained by hand packing. This seems due to the fact that the mechanical packers work at a very inclined angle, and consequently do not force the ballast into contact with the sleepers sufficiently. It appears as if this might easily be remedied by inclining the packer at a smaller angle.

Mr. Jullien. (In French.) — We also employ contractors for maintenance work, or rather we engage our labour through a contractor.

This results in an economy, for our platelayers cost on an average 18 fr. per day, to which should be added about 30 % for general expenses.

In the case of the contractor's workmen, the figure is not as high as this.

The President. (In French.) — How do you arrange for the supervision of the work?

Mr. Jullien. (In French.) — Supervision is carried out by our representatives.

Mr. Quinquet. (In French.) — Our Company has not continued employing contractors for permanent way maintenance, because this was found to be a costly method.

The President. (In French.) — Some time before the war we were asked by Mr. Collet to experiment with his method. He must submit the contract to us on 8 August 1914, but this matter was dropped by reason of the crisis.

Mr. Jullien. (In French.) — On the Orleans line we do not use the Collet machines for maintenance work, but we have sometimes entrusted relaying to Messrs. Collet's firm.

Mr. Barbieri, *reporter.* (In Italian.) — I should like to mention what has been done on the Italian railways. Since 1908 we have entrusted the work of permanent way renewal to private contractors; one of these uses mechanical appliances of the Collet type. We have carried out on the above lines the relaying of more than 1 243 miles of track, and the results obtained have been entirely satisfactory from an economical point of view, as

well as from the point of view of efficiency.

We have therefore proceeded further with this method, and are even employing contractors who do not use mechanical appliances, in accordance with the importance of the line and local conditions.

Latterly we have tried this system for the work of general maintenance over a length of 62 miles, but the results, from an economic point of view, are not conclusive.

Recently, since the adoption of the eight hour day, we have employed, for ordinary maintenance work, two different methods, in accordance with local conditions. In some places we have simply increased the number of temporary workmen in order to compensate for the loss of working hours; in other cases we have let out the work of the general revision to contractors, the material being provided and distributed along the line by the railway administration, which also undertakes the removal of old material withdrawn from the track.

This system has been adopted on quite a large scale in all the departments, except in Sicily and Calabria, where local conditions are not favourable. In Venetia in particular it has given very good results. The Padua section, for example, has repaired 115 miles by means of contractors and has effected an economy of 40 % arising from the reduced cost of labour. This reduction should be more especially attributed to the fact that the contracts in connection with this general revision were largely carried out with temporary workmen whom we had engaged in preceding years by the day for same work. We were thus dealing with labour which was acquainted with the line and the class of work required, and who prefer to work for contractors so that they might work on piece-work, or even for longer than eight hours, which the railway administration were not allowed to arrange with their regular workmen.

The other divisions have not given such satisfactory results as this; however, in the Turin department we have let out by contract the repair of about 25 miles of track, and the results have been equally satisfactory.

In other cases, instead of entrusting the general revision to private firms, we have attempted to carry out the work with our permanent way gangs, but employing mechanical appliances, especially for packing sleepers.

This system has given rise to serious difficulties, because it is not possible to employ it with ordinary gangs. It was necessary to strengthen these considerably so that the work of packing might be continuous and thus render the process economical. After several attempts, we have finally succeeded in packing 95 to 100 sleepers per hour by means of four packers driven by one compressor, thus effecting an economy of 25 % as against similar work carried out by hand.

I should, however, mention that this experiment has not been made on a large scale; we have only two sets of apparatus in use, six others however will shortly be put into service. These results have led us to study methods of extending this system further by entrusting work of general revision, preferably to co-operative societies consisting of former temporary employees of the railway, except where this form of social organisation is impracticable. We shall continue in similar cases to adopt this system, using all kinds of apparatus which render the work easier and more rapid. (*Applause.*)

The President. (In French.) — If I understand rightly, it is your own employees which will become your contractors. If

these do not give you satisfaction, what are you going to do?

Mr. Barbieri. (In French.) — They are employees that are not on the permanent staff.

The President. (In French.) — The contractors with whom you do business are not then members of your regular staff?

Mr. Barbieri. (In French.) — They are auxiliaries, as there are always a number of spare men.

We shall also try, by means of a new system, to find methods to interest the staff of the permanent way gangs in the execution of all kinds of work.

The President. (In French.) — Do I understand by means of a premium?

Mr. Barbieri. (In French.) — We intend to fix a definite time for the execution of work on a given length of track, the value of the time saved will be divided between the workmen and the administration — a premium system in fact.

Mr. Henry. (In French.) — We have adopted in our workshops and stores a system which aims at making it advantageous to the workmen quickly to carry out the work. For example : the length of a particular operation is fixed at sixty hours, if the gang finish the work in fifty hours, we divide the difference with them. We should like to pay on piece work, but the trade union is opposed to it.

Mr. Barbieri. (In French.) — Before the war we had adopted on our railway a system which consisted of fixing the length which each employee should be able to do, this was multiplied by the number of workmen, the value of anything which was done in excess of this was paid to them as a premium.

The President. (In French.) — Is this system easy to apply?

Mr. Barbieri. (In French.) — Very easy. When the basis is fixed it is only necessary to divide the length of line which has been repaired by the number of men who have worked upon it, and it is on the number of metres in excess of the fixed basis that the premiums are paid. These premiums were paid every fifteen days, in accordance with the work done.

The President. (In French.) — Is the work always satisfactory?

Mr. Barbieri. (In French.) — Yes, but I should draw attention to the fact that it is strictly supervised.

Mr. Coomber, Lancashire & Yorkshire Railway. — The opinion that prevails on the English Railways is that the inspection and maintenance work cannot be satisfactorily and economically carried out by contract, and that contrary to the opinion expressed in Mr. Stimson's note, workmen employed by private contractors do not work for a wage inferior to that of workmen employed by the Railway Companies.

Mr. Tintant, French Est Railway. (In French.) — As I understand it the general opinion in England is that the work of repairing lines cannot be economically carried out by private firms.

Mr. Coomber. — That is the general opinion.

The President. (In French.) — Gentlemen, we will pass on to the examination of that part of the question which deals with the inspection of the track itself. This problem has become very important under present day circumstances.

At the St. Petersburg Session in 1892, I had the honour to be a reporter on this question, and I had the good fortune to secure the adoption of the conclusions which I had drawn up, namely, that the

inspection of the line could be reduced to once a day thereby doing away with special men for this work.

These conclusions, which ought to have given an important economical result, have remained until latterly a dead letter in Belgium.

After the armistice, in consequence of the considerable increase in the wages and the reduction in working hours, being responsible at that time for the management of the Way and Works Department, I was led to reconsider the question. I took the initiative of putting into practice the conclusions, the adoption of which I had secured at St. Petersburg.

This measure at the present time is responsible for an economy of close on 1 million francs per year.

I have at the same time proceeded to abolish a large number of the gatekeepers employed at level crossings.

As you know, more than half of Belgium is a flat country, and is traversed by roads and tracks which in many places cross the railway on the level.

We have abolished the gatekeepers at a large number of these level crossings.

The burgomasters, or as you call them in France, « maires des communes », have been asked to warn their fellow townsmen, and special posts have been placed near unguarded level crossings warning the public of the dangers involved.

This measure, which at the present time has resulted in an economy of 3 1/2 million fr. per year, in the first place gave rise to a certain number of isolated complaints. There have been scarcely any accidents arising therefrom.

At the present time the practice seems to be well established, the public having become educated to it.

We have been able to make some progress in this matter, in that Acts passed forty or fifty years ago did not require level crossings on certain lines to be guarded without having given rise to a larger number of accidents than on other lines of the same importance.

It goes without saying that the level crossings on the roads which are frequently used by motor traffic are still guarded, but level crossings on local railways or lines of secondary importance are no longer guarded, or are only guarded during certain parts of day, or even during certain seasons of the year.

In view of the considerable increase in wages, it is evident that this point has impressed the Minister who raised it in the Chamber. It may be stated that a level crossing which is guarded for a whole day of twenty-four hours costs as much as 18 000 fr. per year.

I should be glad if my colleagues would inform us if the experiment of abolishing level crossing keepers has also been made on the lines they represent and if satisfactory results have been obtained.

Mr. Pretorian, Roumanian State Railway. (In French.) — In Roumania there are a considerable number of level crossings which are not guarded, yet the majority of accidents occur at the level crossings which are guarded, and this is to be explained by the fact that drivers of road vehicles, knowing that a level crossing is guarded, cross it without troubling themselves if they see the gates are open, and every case of negligence or absence on the part of the gatekeeper may lead to an accident, while in the case of an unguarded level crossing the users of the road look along the line before crossing over.

It should not be overlooked, however, that the guarded crossings are situated on important lines and roads.

The President. (In French.) — In Belgium the public has always been in the

habit, as far as safety is concerned, of being led by the nose, to use a familiar expression. We have to educate them to the idea that they should look out for themselves.

I noticed while visiting America that in towns of considerable importance, trains cross or even run along the streets for a considerable distance without any disastrous results. Vehicles and pedestrians proceed on either side, and every one looks out for himself.

It it obvious that motor cars which traverse our streets and roads in all directions are much more dangerous than trains which cannot leave their tracks.

Mr. Quinquet. (In French.) — We are glad to learn of the results obtained in Belgium as regards the abolition of level crossing keepers.

We are at present negotiating with the Public Works Department in France in order to secure the adoption of a similar measure, but we are meeting with very strong opposition on the part of road users.

They wish to have the level crossings always open, but provided with electrical apparatus announcing the approach of trains. This method is very expensive, and we cannot think of adopting it.

It is therefore very desirable that in our final summary, attention should be drawn to the very satisfactory results obtained in Belgium and Roumania as regards the abolition of crossings keepers.

Mr. Jullien. (In French.) — In travelling from Florence to Rome, we noticed that many of the level crossings are not guarded.

Mr. Pretorian. (In French.) — A great draw back of the alarm apparatus lies in the fact that it may get out of order and not work when required.

The President. (In French.) — This would be a serious responsibility to the railway in case of an accident.

Mr. Brown, *reporter*. — The question of a reduction in the cost of the maintenance of the track is very important and I consider that methods of standardizing the work should be studied and applied to this end.

A better organisation of the staff, especially by increasing the lengths of sections, and the use of trolleys, should be considered.

As regards the inspection of the track, this is now being done once a day only on several of the more important railways in England.

Unimportant crossings on secondary lines are in some cases not guarded, but simply equipped with cattle-guards. On the main lines, all level crossings are guarded.

Mr. Barbieri, *reporter*. (In French.) — Gentlemen, we had on the Italian railways, before the war, that is to say on about 8 700 miles, 17 000 level crossings and about 17 000 employees to look after them. These employees were also responsible for carrying out minor maintenance work; they also had to inspect the lines, and this inspection took place in many cases four times a day.

As a result of the adoption of the eight hour day, on 31 December 1921, the Italian Government were obliged to increase the number of these employees by nearly one third, which has led to an expense of about 50 million lires. It is therefore bringing in a Bill to allow level crossings which are not in concealed positions to be left unguarded. This measure is about to become law.

Mr. Henry. (In French.) — Has it yet been published?

Mr. Barbieri. (In French.) — It has been published, but the law has not yet been put into force.

At the present time, 6 000 crossings are unguarded, including some on lines which have a traffic of some importance. We intend to deal with other crossings, but gradually.

In accordance with the Law of 1906, we have also entrusted the care of 2 600 level crossings to private individuals. There are 1 300 level crossings on the system which are guarded by gates operated from a distance. In 1 000 of these cases the supervision devolves on the station staff where the crossings may be looked upon as part of the station. Finally, there are 5 500 crossings which are still guarded, and 400 from which the crossing keepers have been withdrawn.

All the level crossings which are unguarded at the present time are those at which pedestrians and drivers of vehicles may see the trains from a sufficient distance. It is easy to distinguish these from the others which are still guarded, because in the case of the former, warning posts are erected on which is displayed a death's head for the benefit of people who cannot read. These posts are frequently preceded at 273 yards along the road by other warning posts which bear a notice of the Italian Touring Club.

Finally, we are going to make tests of a method of automatically indicating to users of the road when a crossing may be used, so as to improve the conditions at level crossings already open in localities where there are frequent fogs and in order to open others where visibility is not very good. This experiment is being made with warning signals, especially of the American type.

The above mentioned Royal Decree has allowed us to reduce the number of inspections down to as few as one every three days.

We are not at present making full use of this concession. We have commenced by one or two inspections per day, and little by little we will reduce these within the permissible limits.

As regards the inspection which the level crossing keepers were required to make, it is intended to entrust this work to a special staff or « gardes-routes ».

The staff who were specially employed to light signals and to lay fog signals in the case of bad weather may also be done away with, if the trials which we are now making on the line from Rome to Orte, where we are about to instal electric signal lamps or acetylene gas flash lights, give satisfactory results.

The reduction in the number of employees makes for very great economy, and when certain journals dispute this point, it is because they only base their arguments on the wages paid before the war, and take no account of those which we have to pay at the present day.

To summarise; by means of the abolition of 3 400 female gate-keepers and 300 male gate-keepers which were employed at the level crossings, and by the transfer to other work of 1 600 male gate-keepers, who have not been discharged because they were part of the permanent staff, we may say that we have effected an economy of staff of about 5 000 employees, and we hope to increase this number to 6 000.

The whole of this measure has already resulted in an annual economy of 30 million lire, a figure which will be doubled when the steps which I have just been mentioning have been fully completed.

Mr. Tettelin. (In French.) — May I ask if the crossings which you consider should not be guarded on account of the

visibility of the trains are situated upon important roads?

Mr. Barbieri. (In French.) — We have commenced by throwing open the crossings on unimportant lines. The instructions of the Central Office have not been fully carried out.

A Delegate. — That is perhaps as well.

Mr. Tettelin. (In French.) — A certain amount of latitude is given then in the application of the rule as regards visibility.

The President. (In French.) — In Belgium, the limit of visibility we adopt is from 328 to 547 yards, and in some cases is greater than this, according to the speed of the trains on the line.

Mr. Barbieri. (In French.) — From 1 January 1921 to 1 March 1922, while we had 6 000 level crossings unguarded, we unfortunately had 51 fatal accidents, but I should say that when all the crossings were guarded, even then there were accidents. In 1918 there were 11 fatal accidents; from 1 January 1921 to 1 March 1922 there were 13 on the lines which are guarded.

The President. (In French.) — The public will becoming accustomed to this.

Mr. Barbieri. (In French.) — We want more notices and warnings and to make use of the press, civil and ecclesiastical authorities, and school teachers. There is no doubt that when the public shall be completely educated in this matter, the number of accidents will decrease.

Mr. Tettelin. (In French.) — I think we might not finish this discussion without saying a few words about a method in use in England which consists of shovel packing the sleepers in place of beater packing them.

The President. (In French.) — The question has already been raised when you were not present. We have spoken of bottom ballast.

Mr. Tettelin. (In French.) — Bottom ballast is not absolutely indispensable. As I see our colleague of the London & North Western Railway is here, perhaps he would be kind enough to give us a few remarks, to which we should listen with much pleasure.

Mr. Jullien. (In French.) — Mr. Trench explained the system yesterday, and is pleased to hear that it is used on the Nord Railway of France.

Mr. Trench, London & North Western Railway. — In England, as in France and Belgium, the question of possible economies in railway maintenance is engaging close attention in view of present day high wages and shorter working hours, but in England the number of level crossings is much smaller than in France and Belgium, also the conditions are very different, so that it is very doubtful whether any economies can be made by dispensing with gatekeepers at main line crossings. Some economies have been made by reducing the examination of the track from twice a day to once a day, and the accounts given by Continental engineers of their experience of still further reducing the number of these visits is of much interest. As to whether any appreciable economy will result from increasing the length of line for which each gang is responsible seems doubtful, but English engineers will watch with interest the experiments in this direction which Mr. Brown proposes to make on the Great Northern Railway.

As to the value of mechanical appliances in track maintenance opinions differ. Hopper wagons and wagons fitted with

ploughs for spreading the ballast, are no doubt economical where a long length of line has to be ballasted, but for ordinary re-ballasting such as is done in connection with relaying, it is doubtful whether the high initial cost of these special wagon trains can be justified. Similarly with mechanical tampers, these save labour where long stretches of line have to be packed, but for ordinary day to day maintenance they are useless. If ordinary maintenance is to be efficient and economical, it is necessary that the smallest defects be repaired immediately. A power driven tamping machine which is difficult to move and interferes with traffic, cannot be used for this purpose.

In reply to Mr. Tettelin's question about shovel packing, this was referred to in the discussion on question I. It is now used exclusively on the London & North Western Railway, and the results have been entirely satisfactory. It is also in use on some French Railways, notably the Nord, where it is understood to be successful when once the workmen have become accustomed to it.

The President. (In French.) — Seeing that it is getting late, we will adjourn the meeting until tomorrow.

Meeting held on 24 April 1922 (morning).

Mr. BRUNEEL, IN THE CHAIR.

Mr. Depoorter, *Secretary.* — Read the minutes on the discussion arising out of question II.

— These minutes were adopted.

The President. (In French.) — We shall not be able to decide today upon the summary of the discussion, Mr. Barbieri being desirous, before he submits it to us, of consulting his English colleague, Mr. Brown.

We shall therefore have to postpone until tomorrow the discussion of the summary dealing with question II.

Meeting held on 25 April 1922 (morning).

Mr. BRUNEEL, IN THE CHAIR.

Mr. Barbieri, *Reporter,* presented jointly, with the English reporter, Mr. Brown, the final summary of the discussion on question II.

It was as follows :

« 1° The attention of permanent way maintenance engineers should be directed to a closer supervision and more systematic control of the work of the maintenance staff, also to such a re-organisation wherever possible as will enable advantageous use to be made of mechanical appliances with a view to greater efficiency and economy;

« 2° One of such methods of reorganisation is to group together at a conve-

nient centre a number of small gangs into one large gang, equipped with means of rapid transport, thereby permitting better supervision, greater efficiency of labour and consequent reduction in the total number of men required;

« 3° A track of ample strength and well-laid in the first instance, is essential to subsequent economical maintenance;

« 4° The employment of contractors for the maintenance of the track is not favoured by all companies. This method may or may not be advantageous according to local circumstances;

« 5° An attempt should be made to extend the use of mechanical appliances for maintenance work;

« 6° Means should be adopted to ensure the economical disposal of material which can be used again and of that which is scrap;

« 7° Except in special circumstances, one inspection of the track per day appears to be sufficient;

« 8° The abolition of gate-keepers at level crossings allows considerable economy to be effected in countries where the law allows them to be abolished. »

The President. (In French.) — The discussion is opened.

Mr. Barrand, *vice-president.* (In French.) — I propose that paragraph 6° be amended as follows :

« It is advisable to make special arrangements to ensure the economical disposal of material which can be used again so as to avoid as far as possible the expense of provisioning and distributing new materials. »

Mr. Brown, *reporter.* — I consider that my wording is more correct as regards the scrap materials.

The President. (In French.) — If the material is really withdrawn from service for a sufficiently good reason, there is no need to trouble about its re-utilisation.

Mr. Brown. — They might take the place of other materials which have to be used by railways, for instance bars for concrete.

The President. (In French.) — That is more a case of obtaining a further advantage of it rather than of making direct use of it.

Mr. Brown. — I think that my draft correctly conveys my meaning.

Mr. Tettelin. (In French.) — It would be better in my opinion to put : « ... special arrangements to sort out material which can be used over again for another purpose. »

Mr. Barrand. (In French.) — Mr. Brown as I understand it is thinking of the sale of scrap material or of its exchange for other material.

The President. (In French.) — As Mr. Tettelin says, we may use the expression « to sort out ».

Mr. Barrand. (In French.) — Quite so, and that being the case there is no need for an amendment.

The President. (In French.) — We must find an English word which correctly corresponds to the words « tirer parti ».

Mr. Brown. — We are quite in agreement.

Mr. Tettelin. (In French.) — In paragraph 1° are the words « closer supervision, and more systematic control of the work of the maintenance staff ».

I think it would be better to say « a close supervision and systematical control ».

I would also like to say that paragraph 5° seems to repeat paragraph 1°, in that it expresses the same idea.

In paragraph 5° it says : « An attempt should be made to extend the use of mechanical appliances for maintenance work », while paragraph 1° read : « a re-organisation wherever possible will enable advantageous use to be made of mechanical appliances with a view to greater efficiency and economy ».

It seems to me that paragraph 5° might quite well be left out.

The President. (In French.) — So much the more since this conclusion goes further than some of us would wish.

Mr. Tettelin. (In French.) — Finally, in paragraph 7° it says « Except in special circumstances, one inspection of the track per day appears to be sufficient ».

I have found that it is more than sufficient. If one adheres strictly to paragraph 7°, one should at least combine it with paragraph 8° which dealt with the abolition of level crossing gate-keepers. It must not imply that this daily inspection is necessary.

The President. (In French.) — I think it will be difficult to rule out the part of the phrase alluded to by Mr. Tettelin, because it expresses the views of a large number of members, at any rate it will be agreed that there is this feeling.

Mr. Tettelin (In French.) — Very well then, but at the same time combine paragraphs 7° and 8°.

The President. (In French.) — Some would abolish them entirely, while others merely contemplate a reduction, but everybody is not in favour of abolishing them altogether.

So that we may all come to an agreement, I propose to delete paragraph 8° and re-word paragraph 7° as follows :

« The reduction or even the abolition of gate-keepers at level crossings and of daily inspections of the track allows considerable economies to be realised in countries in which the law allows these measures. »

Mr. Brown. — As regards 1°, I consider that the word « closer » is necessary because it is by better supervision that it is possible to arrive at a reduction of expenses. (*Exclamations.*)

Mr Tettelin. (In French.) — Seeing that the supervision is already well organised, why say that more should be done in this respect?

The President. (In French.) — I think as a matter of fact that we ought to make a remark that we cannot do any more than is already being done.

Mr. Quinquet. (In French.) — Say « a more strict supervision ».

The President. (In French.) — You also are going to further in this sense Mr. Quinquet?

Mr. Tettelin. (In French.) — When a glass is full there is nothing to be gained by putting any more into it. Will you please translate that for the benefit of Mr. Brown? (*Laughter.*)

The President. (In French.) — I think Mr. Brown is quite ready to agree with us. The English word « systematic » may be right, but in French the word « méthodique » expresses the idea better.

Let us leave it as such in the English, but in the French text put « méthodique ».

— Paragraph 1° in this new form was adopted.

Mr. Brown. — I should point out that the idea in 1° is the use of mechanical

appliances in connection with a reorganisation of the staff engaged on maintenance while that in 5° is the general use of mechanical appliances on such work apart from any reorganisation of staff.

Mr. Tettelin. (In French.) — Our text has a general bearing. It does not only refer to organisation, but also to the inspection of the track. However, I do not insist upon this point.

The President. (In French.) — It is understood then that paragraph 1° is dealing with methods of transport which allow a reduction in the number of gangs by extending their respective lengths, while paragraph 5° deals with mechanical appliances for maintenance of the track, especially sleeper packing machines.

Will Mr. Brown agree if we say in paragraph 1° : « mechanical means of transport? »

Mr. Brown. — No, as by interpolating the word « transport » in 1°, my meaning is circumscribed. I prefer that 5° should be deleted.

The President (In French.) — That is what Mr. Tettelin has proposed.

We agree then to delete paragraph 5° and redraft paragraph 1° as proposed by Mr. Brown, with the reservation that we delete, as decided, the comparative forms. (*Agreed.*)

Mr. Tettelin. (In French.) — Paragraph 7° may be objected to on principle in that it appears to lay down as a rule that the track should be inspected once every day, which is not a universal practice.

The President. (In French.) — Paragraph 8°, as we decided to amend it, will take the place of paragraph 7°.

Mr. Brown. — It seems to me that the rewording of 8° as proposed comes to the same thing as proposing to suppress, at the same time as the guarding of crossings, the inspection of the track.

Mr. Tettelin. (In French.) — There is no obligation to apply this measure, we are merely drawing attention to it as being of a nature to reduce expenses.

The President. (In French.) — Each one can apply it as they wish.

Mr. Brown. — I propose to say, in 7°, that the inspections may be less frequent and may even not be made in certain cases.

Mr. Tettelin. (In French.) — Not in certain cases.

The President. (In French.) — You have been very strong on the point that on a large number of railways no inspection at all is made.

Mr. Tettelin. (In French.) — I would ask Mr. Depoorter, the Secretary, to tell Mr. Brown that the daily inspection is necessary when keyed rails are used. On the Nord Railway of France we have no keyed rails, we cannot therefore admit that we find it necessary to make a practice of inspecting the track daily.

Mr. Barrand. (In French.) — From the point of view of Government control, I should not like the impression to exist that a daily inspection of the track is necessary.

As you know, nearly all the railways in France are controlled by the State. If the control found that this is the opinion of the Congress on this matter, it would act on our advice to require the railways to make this daily inspection, and it would be right in doing so, because the Congress is certainly the most competent technical authority, but on the

Nord Railway of France the daily inspection has been done away with for a long time, and without any unsatisfactory results.

I therefore support Mr. Tettelin's view.

The President. (In French.) — What is true in England may not be so on the continent.

Mr. Brown. — I recognise that the difficulty of coming to an agreement results from the fact that the circumstances are different. I should like to see a phrase added to 7° saying that, in the cases of tracks laid with flat bottom rails, the number of inspections may be reduced and may even be suppressed.

Mr. Tettelin. (In French.) — Under these conditions we agree.

A daily inspection may be sufficient in the case of double headed rails, and it may be done away with altogether in the case of Vignoles rails.

The President. (In French.) — Have the French companies which employ double headed rails any objection to make?

Mr. Quinquet. (In French.) — We still carry out daily inspection, but we are under no obligation to do so, and wish to be free to abolish it if we think necessary.

The President. (In French.) — We will state then that in England a daily inspection is considered necessary. We will thus reserve the opinions of the French companies and systems which use a double headed rail.

Mr. Tettelin. (In French.) — Say that in England, in view of the use of the double headed rail, a daily inspection is considered to be necessary.

Mr. Quinquet. (In French.) — That is also a dangerous statement. If you say that a daily inspection is necessary in England because a double headed rail is used there, one will conclude that it is necessary in France on the systems on which this type of rail is in use. We wish the control to avoid coming to this conclusion.

The President. (In French.) — Would Mr. Tettelin tell us if inspections are abolished on the main lines of the Nord Railway of France.

Mr. Tettelin. (In French.) — There is no systematic daily inspection on any lines of our system.

Mr. Brown. — Here is the new wording that I propose : « Inspection of the track should not be made more than once daily, and under certain circumstances, may be reduced or even dispensed with. »

The President. (In French.) — This amendment puts us all into agreement. (*Hear, hear.*) This is adopted.

DISCUSSION AT THE GENERAL MEETING

Meeting held on 27 April 1922 (afternoon).

Mr. R. DE CORNÉ, HONORARY VICE-PRESIDENT, IN THE CHAIR.
GENERAL SECRETARIES : Mr. J. VERDEYEN; Mr. E. FRANZA; Sir HENRY FOWLER.
ASSISTANT GENERAL SECRETARY : Mr. N. GIOVENE.

Sir Henry Fowler, *general secretary*, read the

Report of the 1st section.

(See *Daily Journal of the session*, No. 8, p. 4.)

« THE PRESIDENT opened the discussion on the maintenance and supervision of the track.

« Mr. BROWN (*reporter*) in the absence of Mr. E. Stimson (*special reporter*) read the summary which the latter had prepared of the four reports of Messrs. Randolph, Brown, Stimson and Barbieri.

« THE PRESIDENT remarked that the summary of Mr. Stimson constituted a complete and well detailed report of the whole question, and proposed to limit the discussion to several particular points, and especially to the methods employed with a view of reducing the cost of maintaining the track. He recalled that when he was reporter on the same subject at the St. Petersburg Congress in 1892, the number of men employed in the repair gangs at that time was the same as that mentioned in the special report just read. He wished the discussion to deal with a new point, and that was whether the throwing together of small gangs really effected an appreciable economy.

« Mr. TETTELIN (*Northern Railway of France*) in reply to this point said that the use of « draisine » automobiles enabled the men carrying out the repairs with their equipment being quickly on the spot where the work was to be done, and also did away with fixed repair outfits. This method was also being tried on smaller lines.

« Mr. QUINQUET (*Paris, Lyons & Mediterranean Railway*) stated that a trial of the system was also being made on the Paris-Lyons-Mediterranean Railway, the « draisines » being provided with portable telephones which allowed communication being made with the adjacent stations, so that they might be informed of the moment the « draisine » was derailed, and the road cleared for traffic.
« This system had given good results on single lines with little traffic. He thought that it would be advantageous to employ more powerful « draisines » for the transport of men and material. A gang provided with a « draisine » automobile ought to be able to look after the maintenance of a section of from 10 to 12 miles.

« Mr. JULLIEN (*Paris-Orleans Railway*) gives an account which will be published

in a forthcoming number of the *Bulletin* on the organisation of the maintenance of the track on the secondary line from Blois to Villefranche-sur-Cher. This line, which is 33 1/2 miles long, has been divided into four sections for inspection, and into two for maintenance. Each of these use a « draisine » for the transport of men and material.

« The difference from the system described by Mr. Quinquet is that on the main line there are a number of sidings in which the « draisines » can be placed. Telephones are provided at these sidings so that the neighbouring stations can be communicated with, and by these means it can be ascertained when the « draisine » may run on the line.

« This organisation works very well, and up to the present has resulted in an economy of about 1 400 fr. per km. per annum.

« The President requested that the subject of the repair of the track by contract should be discussed.

« Mr. Henry (*Eastern Railway of France*) said that before the war maintenance and relaying were carried out by contractors on the Eastern Railway with satisfactory results. It should be stated that the more delicate work of levelling and alignment was carried out by the Company's men.

« Mr. Quinquet mentioned the good results obtained with the Collet system, and called particular attention to the fact that mechanical packing gave a more elastic ballast under the sleeper, than with hand packing.

« Mr. Barbieri (*reporter*) said that since 1908 they had entrusted the repairs of 1 243 miles of line to a private company working with the Collet system. The results have been very satisfactory.

« Since the armistice they had let by contract general repair work. Good results had been obtained especially in the North of Italy. On the Padua section, dealing with the relaying of 115 miles, an economy of 40 % had resulted.

« Mr. Barbieri also called attention to the remarks on this subject (mechanical appliances) in his report. He said that after a couple of trials with mechanical apparatus for boring and packing the sleepers satisfactory results had been obtained. It was possible to pack from 95 to 100 sleepers per hour, economy of 25 % being obtained as compared with similar work carried out by the ordinary method. This success had led Italy to go still further with trials of this description by means of six new machines which are on order. These machines which only carry out a portion of the work required for a general relaying are somewhat inconvenient in that it is not always possible to use them economically as they require working to their full capacity in order to give the best results.

« Under certain circumstances it has been necessary to discontinue working the machine every other day in order to allow the smaller gang of men employed to complete the work carried out mechanically.

« The actual tendency of the Italian State Railways is to have the work of general relaying carried out by co-operative contract. The people employed are old casual employees of the railway, the State finding the necessary material, distributing it along the line and taking charge of the spent and scrap material taken from the track. The Italian State is in reality seeking to obtain the best result by interesting the worker in the work carried out by means of the payment of bonuses.

« Mr. Coomber (*Lancashire & Yorkshire Railway*) stated that the opinion which prevailed on the English railways is that relaying and repairs cannot be satisfactorily carried out by contract. In fact contrary to the opinion expressed by Mr. Stimson in his report, men employed by private contractors would not work at a lower wage than men engaged directly by the companies.

« The President opened the discussion on the inspection of the permanent way, and said that at the Congress at St. Petersburg it was proposed to reduce this to one visit per day. He further stated that at that time it had also been recommended to do away with gatemen at the less important level crossings.

« These recommendations had been put into force in Belgium since the armistice, and had resulted in an economy of more than 1 million francs in inspection, and of 3 1/2 million francs by doing away with the gatemen at certain level crossings. This latter procedure had not resulted in any untoward incident, and now seem to be well established.

« He asked if similar arrangements had been introduced on other railways.

« Mr. Pretorian (*Roumanian State Railway*) said that on the railways he was associated with only the more important level crossings had gatemen.

« Mr. Quinquet said the results in Belgium had been favourable, and hoped that similar measures would be taken in France.

« Mr. Brown said he fully appreciated the importance of the diminution of the cost of repairs of the track, and thought that standardisation of work ought to be applied in this case. The better distribution of the men, especially by the increase of the length of the section ,and the utilisation of « draisines » ought to be considered. With regard to the inspection of the road, this was only done once a day in England. On the less important crossings on branch lines no gatemen were provided, but they were simply furnished with « cattle guards »; on important lines all level crossings were guarded.

« Mr. Barbieri said that on the Italian railways they had 17 000 level crossings, certain of which were not guarded before the war in conformity with the regulations of the law on guarding crossings.

« The introduction of the eight hour Act had caused a Royal decree to be promulgated authorising the Italian State to dispense with gatemen at all level crossings which are sufficiently visible from the road and the rail. These regulations will be gradually applied ,and will finally result in the withdrawing of gatemen from about 6 000 level crossings, which are however to be provided with warning boards.

« Experiments are being made with a view to providing automatic signals at the more important level crossings or where these were not sufficiently visible, in order to do away with gatemen at these points.

« The number of inspections of the line has also been reduced to a minimum of one per day on the less important lines. The result of these steps has already effected an annual economy of 30 million, a figure which will be doubled when the regulations mentioned above have been applied universally.

« In order to reduce the number of men engaged in lighting and control of signals, the Italian State Railway will carry out experiments on the Rome-Orte line with a view to utilising electric light or acetylene with a flickering flame for lighting signals.

« Mr. Trench (*London & North Western Railway*) stated he had listened with interest to the points which Mr. Brown had raised on the subject of the reorganisation of the repairs staff, and particularly the one relating to the increase of the sections looked after by one gang. On the subject of the use of mechanical apparatus, Mr. Brown called attention to the good results obtained by means of hopper wagons arranged to discharge automatically.

« With regard of the employment of mechanical packing devices for ordinary repairs, Mr. Trench thought that the difficulties of management had been surmounted to a great degree. He believed that a good result should be obtained from the use of machines on ordinary repair work, as any small defect could be dealt with on the spot. The machines however ought only to be used on lines of certain importance. »

The President. — This is the

Final summary.

« 1° The attention of engineers in « charge of maintenance of track should be « directed to close supervision and syste- « matic control of the work of the main- « tenance staff, also to such reorganisa- « tion, wherever possible, as will enable « advantageous use to be made of me- « chanical appliances, with a view to « greater efficiency and economy;

« 2° One of such methods of reorgani- « sation is to group together at a conve- « nient centre a number of small gangs « into one large gang, equipped with « means of rapid transport, thereby per- « mitting better supervision, greater effi- « ciency of labour and consequent reduc- « tion in the total number of men « required;

« 3° A track of ample strength and well- « laid in the first instance, is essential to « subsequent economical maintenance;

« 4° The employment of contractors for « the maintenance of the track is not fa- « voured by all companies. This method « may or may not be advantageous ac- « cording to local circumstances;

« 5° Means should be adopted to ensure « the re-use of any serviceable material, « in order to save the expense of supply- « ing new material, and at the same time « to discard any material which is con- « sidered as unfit for further use;

« 6° Inspection of the track should not « be made more than once daily, and un- « der certain circumstances may be re- « duced or even dispensed with;

« 7° Where legislation permits, reduc- « ing or even abolition of level-crossing- « keepers offers further possibilities of « effecting considerable economy. »

— The general meeting ratified this summary.

[625 .17] APPENDIX 1.

Note on the organisation of the maintenance of permanent way on the local line from Blois to Villefranche-sur-Cher,

By Mr. ALBAGNAC.

The local line from Blois to Villefranche-sur-Cher is 54 km. 366 (33.782 miles) in length and is split up into four sections (C. S.) for inspection and into two sections (D. R.) for maintenance, each of the latter having a « draisine » automotor for transport of staff and material. In all it forms a *group of section* under a permanent way inspector in his turn under a district superintendent who has the supervision of other ordinary sections elsewhere.

Inspection sections C. S. — Each section C. S. is from 13 to 14 km. (8 to 8.7 miles) in length and is looked after by a platelayer who lives at one end of his section. This employee ought to use going or returning an ordinary train for the daily journey he has to make over his section.

The platelayer is directly under the permanent way inspector; his work is defined by General Order 6, articles 25 to 34. He will be expected to look after:

the cleaning and greasing of the points;
the repair of signals, signal wires, etc.;
the supply of oil to the lamps at level crossings;
the lighting of certain signals;
the repair of damage and urgent packing of ballast when the importance of the work does not necessitate the presence of the maintenance gang, preventing the line being flooded with water; cleaning out the ditches and drains, seeing that the rail joints are in good condition, etc. In a word he has to carry out all the urgent work which can be done by a single man.

In addition, he should be expected to carry out the following little jobs: painting the signals, gates and small metal structures, repair of displaced ballast, replacement of stone sets, etc.

The platelayer each day sends in a report to the permanent way inspector stating how his time has been employed and what various points have come to his notice as well as any defects he may have seen.

Maintenance sections (D. R.). — The maintenance sections are about 27 km. (17 miles) in length; each of them is supplied with a « draisine » automotor and a « diplorry » for the transportation of staff and material. The gates at the level crossings are left open at night. The men working on these sections are not provided with houses but are required to live at Romorantin and Cour-Cheverny, at which places the « draisines » are housed and where there are stores for material. If they ask for it, their wives are given charge of crossing gates in the neighbourhood, but if this arrangement is made, the men are not allowed to include « walking time » from the crossing to the yard in their eight hours work.

The men make, but not included in the eight hours, a journey of 2 km. (1.2 miles) — say half an hour — in order to arrive on the repair section, this time not being counted when it is less than half an

hour. If the time exceeds half an hour, it counts as half time except in the case of the driver of the « draisine ».

The staff in each section consists of eight men, namely : a ganger, an assistant ganger, four platelayers and two auxiliary men, or better perhaps 600 man-days per annum of auxiliary labour. The six maintenance men in each section share with the inspection platelayers the inspection on Sundays and holidays of the two inspection sections which form their repair section.

The repair work is laid out so that each section is thoroughly overhauled every eighteen months, which means the average length dealt with each week is 350 metres (383 yards). This is not excessive for eight men when it is remembered that the inspection of the line is provided for and that the men are carried to their work by an automotor. This overhaul every eighteen months in place of four years increases the life of the sleeper materially and maintains the road as a whole in better condition.

The running of the « draisines » is governed by Instruction 464 as amplified by note 24625 of 15 October 1921. In accordance with these the points at which the « draisine » is stopped on the main line are coupled up by telephone with a signal box when the distance between two consecutive points exceeds 5 km. (3 miles). Each « draisine » is provided with an arrangement allowing it to connect with the telephone circuit when the place at which it stops is not permanently fitted for making such a connection.

The « draisine » is also provided with a « sauterelle » allowing it to be laid out of the track in case no switch or turning table would be at hand.

The maintenance gangs are placed directly under the order of the permanent way inspector to whom they send their daily journals. They are excused the weekly turn laid down by article 25 of General Order No. 6. The assistant gangers take charge of the running of the « draisine ».

Permanent way inspector in charge of the sections. — The permanent way inspector has under his orders all the men engaged on inspection and maintenance as well as the level crossing keepers.

He carries out the duties of chief of sections as laid down by General Order No. 6 and which deals with the supervision of inspecting platelayers and weekly examinations and those of the district superintendent which deal with level crossings, inspection and maintenance of the permanent way, apparatus, movable and fixed signals, earthwork and other works with the exception of buildings, the maintenance of which is dealt with by the district superintendent.

He looks after the distribution of stores and tools.

Each day he sends in his report to the district superintendent, attaching to it the reports of the inspecting platelayers and section gangers.

District superintendent and sectional chief. — The district superintendent carries out the duties laid down by General Order No. 5, except that it is not required that he walk over the district and need only go over it on an engine once every two months in place of walking over it three times each month and going over it on an engine every month. The « virtual » length of the line from the point of view of these journeys is therefore only about $\frac{54 \text{ km.}}{6} = 9$ km. (5.6 miles).

The sectional chief need not walk over the line, and is only required to go over on an engine once every four months.

Level crossings which are guarded. — The line has only 22 crossings which are guarded, eight of which have gatekeepers who are not wives of railway servants. The new organisation allows of ten men having houses at level crossings, two

being inspecting platelayers at level crossings 213 and 214, and probably it will be arranged that eight of the maintenance gangs will be placed at level crossings near Romorantin and Cour-Cheverny. This will make it necessary to engage four level crossing keepers (not wives of railway men).

Economies realised by the new organisation.

Reduction of staff.	1 second class district superintendent at a mean salary plus expenses of 10 000 fr.		10 000 fr.
	5 gangers at a salary of 6 700 fr.		33 500 —
	11 platelayers at a salary of 5 850 fr.		64 350 —
	Total.		107 850 fr.
Increase of staff.	1 permanent way inspector at a salary of	7 300 fr.	23 300 fr.
	4 crossing keepers with increase of salary (300 + 100 = 400 fr.)	1 600 —	
	1 200 man days by auxiliary labour at 12 fr.	14 400 —	
	Economy of staff.		84 550 fr.
	from which must be deducted :		
Depreciation and maintenance of « draisines », two at 1 000 fr.		2 000 fr.	10 000 fr.
Petrol 3 000 l. at 1.50 fr.		4 500 —	
Lubricating oil 400 kgr. at 5 fr.		2 000 —	
Sundries		1 500 —	
	Net annual saving per annum.		74 550 fr.

or about 1 400 fr. per km. of line at the cost of 37 500 fr. for each « draisine » used.

November 1921.

[625 .17]

APPENDIX 2.

Note on the maintenance and supervision of the track,

By H. DEYL,
ENGINEER,
ADVISORY SUPERINTENDENT OF RAILWAY CONSTRUCTION ON THE CZECHO-SLOVAKIAN STATE RAILWAYS.

I. — In order to ensure continuity in railway working after the *coup d'État* in 1918, the Czecho-Slovakian State railways have been carried on as a whole as if under the former Administration and without any great changes. Nevertheless the Ministry of railways at Prague gives particular attention to questions of railway organization and has established a department for the study of these questions.

The Czecho-Slovakian State railways are split up into seven divisions, each dealing with from 792 to 1 311 miles of track. According to the density of the traffic, each division is subdivided into maintenance sections from 40 to 150 km. (25 to 93 miles). These sections are also, according to the importance of the line, subdivided into districts of three classes; up to 7.5 miles; from 7.5 to 10.5 miles and from 10.5 to 18.5 miles.

The executive authority over the whole of the traffic service is concentrated in the hands of the Manager. The divisions of the State railways usually comprise eight departments, each dealing with the matters with which it is concerned.

The head of the maintenance and inspection branch is the chief of the particular department on the railway Directorate. This branch is divided into eight distinct groups: foundations of the track, large constructional works (bridges and tunnels), buildings, permanent way, signals, staff and establishment, clerical and accountancy, stores and supply of materials and tools.

The chiefs of the maintenance sections have assistants and one or more engineers, apart from the ordinary staff for the clerical and storekeeping work. The districts are managed by the district chiefs who are provided with the necessary gangs of workmen for maintenance together with their foremen, and the inspecting staff for the track, watchmen, etc.

The maintenance and inspection branch is quite independent of the other branches dealing with traffic.

II. — *Maintenance branch.* — Up to the present time it has not been found necessary to subdivide the districts into sub-districts, but this question is under consideration. It has not, hitherto, been necessary to form special gangs of workmen for carrying out the work of reconditioning or renewing the track. The number of men allotted to regular maintenance is determined for each line by comparison with a main line of average importance. The number of men in the gangs is calculated on the basis of 2.9 workmen per mile.

The local gangs are temporarily strengthened by temporary additional labour in the case of heavy maintenance work.

Under the legal statutes dating from 1920 temporary workmen automatically become permanent (on the staff) after ten years continuous work.

The method of maintenance known as « general revision » is being tried.

The maintenance proper of the permanent way is entirely carried out by the ordinary staff. Other work is, as far as possible, given out to private contract, particularly in the present condition of slackness.

When the track is to be renewed the complete reconstruction of the permanent way is undertaken including renewal of the ballast; as far as possible the new track is put together alongside the old and shifted laterally into place.

Double-headed rails weighing 84.9 lb. or 94.9 lb. per yard carried on cast-iron chairs and secured by wooden keys are used almost exclusively in damp tunnels of great length. The ordinary equipment of the Czecho-Slovakian State railways consists exclusively of Vignoles rails weighing 71.87 lb. or 89.40 lb. per yard according to the traffic on the line. On light railways, rails are used weighing 52.72 lb. per yard.

The rails are secured to the sleepers by means of wedge-shaped saddle-plates, which are themselves secured by dog spikes or screw-spikes.

The normal length of the rails is 49 ft. 3 in. for main lines; for secondary lines and light railways the length is 41 feet.

The Czecho-Slovakian State railways use sleepers of untreated oak; beech is also used treated with créosote, and resinous woods, fir and larch, are used treated with a mixture of créosote and zinc chloride.

In order to prevent the production of longitudinal cracks in the sleepers the ends are bound with hoop iron 3/32 by 25/32 inch tightened by a lever and secured by means of wrought iron rails about 1 5/8 inches long driven into the sleeper.

The results obtained by this method are very satisfactory.

The chief of each district has a store of materials required for maintenance of which he must keep account and submit this to the head of the section. The materials removed from the track when reconstruction is in progress are sorted and repaired; if useless they are sold as scrap. The old and useless sleepers are

used up in the locomotive sheds for lighting the fires; the balance is sold to the staff.

III. — *Inspection service.* — The line is placed under the supervision of the head of the section and the chiefs of the districts. The inspection service comprises, besides the level-crossing watchmen, the signalmen and also the track-watchmen.

The track-watchmen usually go over the track from one to three times a day, according to the traffic on the line.

The chief of the district goes over the line in his district daily either on foot or by train. The head of the section inspects the part of the track, for which he is responsible, three or four times a month.

The track-watchmen may be given duties of two kinds :

a) Mixed service, as when the level-crossing keeper is required to inspect the length of track allotted to him in the time between trains. In this case the track to be inspected usually comprises a length of 0.62 to 1.2 miles; on lines carrying light traffic the level-crossing keeper may have a considerable length to inspect;

b) So-called separate service, which differs for the track-watchmen and the level-crossing keepers. In this case the level-crossing keeper does not leave his post; the track is inspected by a special track-watchman. The length of track allocated to the track-watchman is determined by the number of times he must cover it daily, and may be 2.5, 3.7 or even 7.5 miles, when he can get back by train; and a length of 1.9, 2.5 and up to 3.7 miles when the return journey must be made on foot. The maximum distance covered on foot by the track-watchman must not exceed 10 miles.

This division of the work of inspection is advisable when the intervals between the trains do not admit of sufficiently careful track examination by the level-crossing keepers. This is the case when the service amounts to about thirty trains a day.

This dividing of the service has economic advantages and also is more efficient, particularly on lines carrying heavy traffic. This does not apply to lines carrying light traffic because it is impossible to keep the level-crossing keepers fully occupied.

The gates are operated from a distance up to 1 600 m. (1 mile) from the level-crossing keeper's station, according to the importance of the crossing, its width, etc. On lines carrying trains that run at speeds of up to 25 miles per hour, there are only gates at level-crossings that are of special importance.

With a view to effecting economy in the staff engaged in the inspection of the track a reduction in the number of daily inspections of the track has been considered; the abolition of level-crossing keepers on light railways of small importance has also been considered. On these lines it is proposed to replace this inspection by rounds made by the workmen when going to their work or returning from it, a more careful examination being made at longer intervals (once a week for example).

The use of the women's auxiliary service in the inspection of the track is confined to working the gates.

The gates at level-crossings are only lighted on busy town roads. On other roads over which many automobiles run means are taken to warn approaching vehicles by means of small special reflectors, two or more in number attached to the gate, which at night reflect a red light when illuminated by the head lights of the motor car. Other crossings are not lighted. Moreover, in order that the gates may be made visible even in a half-light, they are painted white with black bands.

[625 .143.2, 625 .15 & 669 .1]

QUESTION III

SPECIAL STEELS.

Use of special steels, both for the track generally, and in particular for the track appliances (points, crossings, etc.).

Preliminary documents.

1st report (America), by Mr. W. C. Cushing. (See English edition of the *Bulletin* of June 1921, p. 577, or separate issue [with red cover] No. 16.)

2nd report (all countries, except France and America), by Mr. Sand. (See English edition of the *Bulletin* of September 1920, p. 563, or separate issue [with red cover] No. 6.)

Supplement to the 2nd report, by Mr. Sand. (See English edition of the *Bulletin* of August 1921, p. 1103, or separate issue [with red cover] No. 26.)

3rd report (France), by Mr. Mesnager. (See English edition of the *Bulletin* of December 1921, p. 2025, or separate issue [with red cover] No. 45.)

Special reporter : Mr. Mesnager. (See English edition of the *Bulletin* of April 1922, p. 730.)

SECTIONAL DISCUSSION

Meeting held on 21 April 1922 (morning)

Mr. BRUNEEL, IN THE CHAIR.

The President. (In French.) — Gentlemen, before commencing the discussion relating to question III, I wish to fulfil a solemn duty in memory of one of the most highly esteemed of our colleagues, the late Mr. Sand, one of the reporters of this question III.

Mr. Sand, who was vice-president of the Swiss Federal Railways, was a prominent figure in the technical work of the Confederation. He participated in all the most important railway schemes executed on Swiss territory, and I may specially mention the laying out of the stations at Basle, Lausanne and Vallorbe, and above all the great work of piercing the Simplon tunnel and its approaches. In all the vast enterprises in which he assisted, Mr. Sand showed untiring energy, a sound judgment and a scientific knowledge that was quite remarkable.

I feel sure that I voice the unanimous feelings of this section in paying solemn

homage to his memory, and offering to his family and our Swiss colleagues our heartfelt condolence at the great loss we have all sustained by the death of one whose interesting work will shortly be dealt with. (*Applause.*)

I now call on Mr. Mesnager.

Mr. Mesnager, *special reporter*, read (in French) a summary of the special reports on question III (see the summary published in No. 4 of the *Bulletin* for April 1922).

The President. (In French.) — We thank Mr. Mesnager for his very lucid summary. As he says, Mr. Cushing's report was most complete, and we should obtain much useful information from it.

We have to look at the question from a general point of view without entering into details of manufacture.

There is a passage in Mr. Cushing's report (page 46) (1) to which I should like to call your attention.

This states :

Nearly all railways are opposed to interference in the processes of manufacture, believing instead in the principle of specifications for rails which set forth clearly and concisely the physical qualities which they must have, and the methods of conducting tests which will prove that the product offered for sale does or does not possess those qualities.

This is a very interesting point for the Belgian railways, because we have decided to follow the example of our French colleagues, and I should be glad if they would kindly give us details of their specifications for the manufacture of manganese steel rails.

(1) See number for June 1921 of the *Bulletin*, p. 577.

Mr. Jullien, Paris-Orleans Railway. (In French.) — The French Companies issued no special specifications for manganese steel, but requested the manufacturers to supply steel containing 13 % of manganese. Up to now they had not considered it necessary to alter this proportion, and are satisfied with the results obtained.

The President. (In French.) — I congratulate the French manufacturers on being able to inspire you with so much confidence in themselves.

Mr. Jullien. (In French.) — I would like to put several questions to my English speaking colleagues.

First of all, has the use of manganese steel stopped the fitting of spring crossings? Are these still in favour?

Secondly : According to the information given in the report, the cost, in Great Britain, of apparatus made in manganese steel is three times that charged for ordinary steel; in France, the cost is only twice that of apparatus in ordinary steel. This is a most interesting subject, as it suggests the question whether the rate of wear compensates for the difference in price.

On the Orleans Railway use is made of reversible parts which enables them to be used on both sides. The crossings in manganese steel are provided with a very solid bearing surface, and we are very satisfied with their behaviour.

In 1916, I noticed that on the Pennsylvania Railroad the manganese steel crossings which had been in use were sent back to the works where they were practically made as good as new by rounding them slightly, which took out the wear, and then afterwards grinding them.

Thirdly : What is the present position

in England as regards the rolling of manganese steel rails?

Mr. Cooper, City & South London Railway. — Crossings with springs are occasionally used. For the last twenty years ordinary crossings have been made of manganese steel; these crossings give satisfactory results and a considerable economy is realised if their cost is compared with that of ordinary steel. I estimate one can, as a general rule, allow that the life of these crossings in manganese steel is from six to ten times longer than that of the same crossings in ordinary steel.

As regards the prices, I can only give indications referring to the pre-war period. Manganese steel cost £27 per ton and ordinary steel cost £7, or about four to one.

Manganese steel rails are used in some curves of small radius and on lines with much traffic where the wear would be very great. To give an idea of the greater durability of manganese steel rails, I should point out that where ordinary steel rails lasted twelve months, we substituted five years ago manganese steel rails which are still in service and we hope that they will last another three years.

In very sharp curves it has been ascertained that the rails must be withdrawn not because of excessive loss of weight, but on account of undulatory wear.

Rails of sorbitic steel tested in certain districts have given satisfactory results but have had to be rapidly withdrawn from service as compared with rolled manganese rails. The advantage of sorbitic steel figures out at 80 to 90 % over ordinary steel as regards reduced loss in weight. However, on sharp curves the advantage is only 40 %, the sorbitic steel only giving this additional life against undulatory wear.

Mr. de Boulongne, Paris-Lyons-Mediterranean Railway. (In French.) — Manganese steel has two advantages, one, already mentioned, is that by its use, wear is lessened, and the other is that it allows the possibility of casting crossings in one piece instead of building them up of several rails.

On the Paris-Lyons-Mediterranean we consider that a crossing cast in one piece is preferable to one made up of rails fitted together which deteriorate not only by wear, but also by distortion.

We should be glad to know if the result of the trials made by our American and English colleagues has been favourable to a crossing cast in one piece.

It is understood that manganese steel may be used for building up angles and crossings, but I think it will at once be seen that in doing so, a portion of the advantages that this steel offers is lost, for as I have just pointed out, the parts not only deteriorate by wear, but also by distortion.

Mr. Jullien. (In French.) — Before the war the Orleans Company used crossings that were built up in manganese steel, and we must admit they answered very well. Since the armistice, however, on account of the difficulties we had in obtaining this material, we were obliged to make use of crossings in manganese steel cast in one piece. We were very glad indeed to find works that were able to supply us, and the crossings have given every satisfaction to the engineers, who, however, agree in pointing out that they have one weak point, namely, the connection to the rail, and that it is necessary to make the part of the crossing forming the fish plate very strong, for when this breaks the whole apparatus is scrapped. With this reservation we have

found that the cast steel crossing gives excellent results.

Mr. Cambournac, French Nord Railway. (In French.) — It cannot be a question of making an absolute rule concerning this form of crossing or even recommending one system rather than another.

It is certain that on certain parts of the track, on curves for instance, the fixing of a crossing cast in one piece that cannot be altered in shape is much less convenient than one that can be built up according to circumstances.

At stations where traffic is small there does not seem to be anything to be gained by changing crossings built up of ordinary rails for ones of solid castings in manganese steel which are so very much dearer. If these are found advantageous on lines of heavy traffic, it is not the same thing on lines where traffic is light, all the more so, as I said before, because the difference of price is considerable.

Mr. Balling, Paris-Orleans Railway. (In French.) — I agree in what my colleague, Mr. Cambournac, has just said, namely, that the use of crossings made in cast manganese steel is much more costly than with those made of built up rails in ordinary steel. From this it is certain that on lines where traffic is light it is preferable to keep to the latter.

For important lines, the Paris-Orleans Company orders crossings of manganese steel only, the old type being removed and used up on the less important lines where they will render good service for some time to come.

Mr. Cooper. — On the London Underground Railways monoblock crossings (cast manganese) have been used and also crossings made up of rolled manganese rails bolted together.

The former give good results on lines where the speed is not great, as on the London Tube Railways. Some manganese crossings have had to be withdrawn after a relatively short life due to defects such as blow holes in the castings. For this reason, and the easier running even at low speeds, it is preferable to make use of crossings built up of rolled manganese rails.

Mr. Willem, Belgian State Railway. (In French.) — The question of attachment to the ordinary rail has been solved in Belgium as follows :

We require that the cross section of a crossing in manganese steel shall be finished off with an end made to the section of the rail to which it is joined up, this being formed in the casting.

In Belgium, crossings made of manganese steel are especially used for crossings on roads where the conditions of maintenance are not always as good as they might be and where wear is more largely due to local conditions rather than to the legitimate wear of the rails.

From the time when crossings were made in one piece, the inconvenience diminished greatly, though unfortunately since the armistice the price of manganese steel is such that we have been obliged to discard the use of it.

A few months ago we inquired for prices from English and French firms. Crossings of English make were, on account of the exchange, from six to seven and even eight times the price of built up crossings well made. Though the French firms would have supplied us at a relatively low price per kilo (about 4 francs), we made this strange discovery that their all round price exceeded that of the English firms. This was due to the fact

that the total weights differed considerably, so we could not form a basis for comparison.

I may also point out that the matter being thrown open to public contract, a number of new firms have taken up the manufacture of manganese steel. As formerly some of them were only manufacturers of crushing mills, we have not been able to place entire confidence in them. These manufacturers seemed only alive to one thing, and that was that a new outlet for trading had opened up.

We give no details in our specification in Belgium, which is a matter that should be remedied as soon as possible, and it would be very interesting to hear what details are inserted by other companies in their specifications.

Mr. Schrafl, Swiss Federal Railways. (In French.) — Manganese steel crossings cast in one piece and which have been on trial since 1910 on lines where the traffic is heavy have given very good results, and after twelve years of service it is yet quite impossible to say, even approximately, how much longer they may last before renewal will be necessary.

I think, however, that these crossings have two serious faults. As manganese steel cannot be cut with a tool, it is necessary to have the fish plates specially fitted to each one, and if one of these plates broke it would not be possible to replace it as quickly as the circumstances might require. In addition, in Switzerland these crossings are very costly (much above the price quoted by the French Railways) and this, except for particular cases, renders their general use prohibitive.

Manganese steel is at the same time ductile, strong and very hard, and offers a great resistance to wear. These qualities, however, are not essential for all parts of a crossing, and are only really useful for those pieces or parts of pieces which receive blows or have to withstand friction. If manganese steel is only made use of for these purposes, it is possible to obtain built up crossings having a life equal to those crossings cast in one piece at a much lower cost, and with the advantage of being able to apply without difficulty ordinary fish plates for joining up purposes.

For some years past, with this object in view, insertion parts of manganese steel have been fitted to the wing rail of a certain number of crossings at the place where the tyre passes from the point to the wing rail or inversely. The crossings of built up rails fitted in this way and of which ten have been put down since 1912 in lines branching into stations are perfectly intact at the present day.

This system has therefore proved satisfactory, and insertion parts of manganese steel on crossings and other permanent way work would have been much more frequently used in Switzerland if the war and the economical consequences which resulted from it had not forced the utmost care to be taken with regard to expenditure, but as soon as circumstances are more propitious, recourse will be had to this method again.

Mr. de Boulongne. (In French.) — I would like to ask Mr. Cooper, who stated just now that it had been necessary to prematurely take out of service crossings in cast steel on account of the material losing its nature, whether this referred to a crossing of the old type or to one recently constructed?

I know that when first put into use cracks occurred in crossings made of manganese steel. These faults were found

to be due to the process of manufacture which was not then sufficiently understood. As far as my own experience goes, the new crossings are much better.

Mr. Cooper. — The monoblock crossings to which I alluded were cast between 1904 and 1912 and the crossings changed for defects were generally speaking due to blow holes which developed in the nose of the crossings.

I consider that the built up manganese crossings which are now made are very successful.

Mr. de Boulongne. (In French.) — As actually manufactured, could it be definitely stated that a crossing cast in steel in one piece contained all the qualities that were desirable?

The President. (In French.) — All those with wide experience, the English especially, were of opinion that every confidence might be placed in it; any trouble which occurred was during the period when the first trials were being made.

Mr. Deyl, Czecho-Slovakia State Railway. (In French.) — The administration of the Czecho-Slovakia State Railway was proceeding, though so far only on a relatively small scale, in making trials of rails of manganese steel and Titanium steel, with a view to increasing their life, especially on steep gradients, sharp curves, and on lines where the traffic is heavy.

These trials are so recent that it is not yet possible to give sufficient results from which a definite opinion could be formed as regards special steels.

The chemical analysis of the special steels used gave average results as follows :

—	Titanium steel.	Manganese steel.
	°/o	°/o
Carbon	0.54	1.08
Manganese	0.72	11 06
Phosphorus	0.040	0.065
Sulphur	Unknown.	0.017
Silicon	0.125	Unknown.
Titanium	0.009-0.01	...

The chemical composition of the ordinary steels in use varies within the limits stated below :

—	Ordinary steels				
	Thomas.		Martin. Siemens-Martin.	Martin.	Talbot.
	Year 1920.	Year 1921.	Year 1921.	Year 1920.	Year 1921.
	°/o	°/o	°/o	°/o	°/o
Carbon	0.50 to 0.64	0.50 to 0.59	0.25 to 0.63	0.36 to 0.55	0.36 to 0.55
Manganese	0.41 to 0.78	0.50 to 0.73	0.49 to 1.51	0.70 to 1.20	0.70 to 1.32
Phosphorus	0.019 to 0.089	0.034 to 0.088	0.016 to 0.082	0.030 to 0.090	0.30 to 0.90
Sulphure	0.026 to 0.079	0.030 to 0.078	0.027 to 0.091	0.12 to 0.55	0.44 to 0.55
Silicon	Result unknown.	Result unknown.	Result unknown.	0.08 to 0.13	0.07 to 0.11

The mechanical tests of ordinary steels and of titanium steel made during the years 1920 and 1921 gave the following results :

TENSILE LIMIT.	Thomas steel.	Martin Siemens-Martin steel. (Year 1921.)	Martin Talbot-Martin steel.	Titanium steel.	Manganese steel.
Limit of elasticity, in kilograms per square millimetre (in lb. per square inch).	32.7 to 42.3 (46 510 to 60 160)	34.5 to 44.5 (49 070 to 63 290)	35.0 to 42.3 (49 780 to 60 160)	37.3 to 41.4 (53 050 to 58 880)	No tests made.
Ultimate tensile strength, in kilograms per square millimetre (in lb. per square inch)	65.1 to 78.6 (92 590 to 111 790)	64.6 to 85.0 (91 880 to 120 890)	63.6 to 84.9 (90 460 to 120 750)	68.6 to 76.7 (97 570 to 109 090)	
Elongation, % on 200 mm. (7 7/8 inches)	10.0 to 17.5	3.0 to 17.0	7.5 to 20.5	4.0 to 17.0	
Reduction of area % . . .	15.5 to 32.0	10.2 to 41.5	8.0 to 47.0	4.5 to 37.6	
Brinell hardness	230 to 243	200 to 230	177 to 195	Unknown.	

The drop tests of special steel rails were made with a falling weight of 500 kgr. (1 100 lb.) and the length of rail fixed on supports 1 m. (3 ft. 3 3/8 in.) apart. With type A manganese steel rails, the first blow is from a height of 6 m. (19 ft. 8 in.), and the succeeding blows from a height of 2 m. 4 (7 ft. 10 in.). With type X*a* titanium steel rails, the first blow was from 5 m. (16 ft. 5 in.) and the following blows from 2 m. (6 ft. 7 in.).

—	Deflection noticed after the 1st blow in millimetres (in inches).	2nd	3rd	4th	5th	6th	7th
Rail type A of manganese steel . . .	48 (1 29 32)	65 (2 9/16)	82 (3 1/4)	98 (3 7/8)	114 (4 1/2)	129 (5 3/32)	172 (1) (6 13/16)
Rail type X*a* of titanium steel	39 (1 9/16)	51 (2)	61 (2 3/8)	71 (2 13/16)	81 (3 3/16)	91 (3 5/8)	101 (4)

1) For this blow the weight was allowed to fall from a height of 6 m. (19 ft. 8 1/4 in.)

For drop testing rails of ordinary steel, a weight of 500 kgr. (1 100 lb.) is used with rails of type A. In all cases supports are placed 1 m. (3 ft. 3 3/8 in.) apart with rails of type A. The first blow is made from a height of 5 m. 86 (19 ft. 3 in.), and succeeding blows being from a height of 2 m. 38 (7 ft. 10 in.). With rails type X*a*, the first blow is from a height of 4 m. 52 (14 ft. 10 in.), and the following blows from a height of 1 m. 80 (5 ft. 11 in.). In the case of type A rails, a deflection of 86 mm. (3 3/8 inches) and type X*a* rails 94 mm.

(3 23/32 inches) must be given before breakage takes place.

In my opinion a study ought to be made of the following questions :

1° To find the chemical composition and methods to employ in order to obtain from ordinary steel rails an increased resistance to wear without brittleness and avoiding at the same time any damage to the flanges of the tyres;

2° In the same way, to choose special steels — that is to say, steels of a special chemical composition or produced by a special process of manufacture — for those parts of the line where wear is found to be particularly rapid;

3° To investigate the causes of cracking of rails and fish plates, and find means to prevent these cracks forming, in order to ensure safe running.

Mr. Cambournac. (In French.) — It would be desirable to obtain particulars with regard to lines on which heavy traffic takes place and which are laid with Sandberg rails, as the price of these rails is lower than those made of manganese steel.

Mr. Sandberg, Ministry of Communications, China. (In French.) — I think I am in a position to say that when the report of Mr. Cushing was drawn up. *i e.*, more than one year ago, the results of the tests made on the Pennsylvania Railway were not then fully known; it is probable that he would have reached other conclusions if he had made is report after Mr. Shand, engineer in chief, had published the diagrams on the tests with the sorbitic rail.

Mr. Shand has kindly informed me of the results obtained and has given me permission to publish them.

These diagrams show that rails of Sandberg sorbitic steel have an increased life of 85 % against an extra cost of manufacture of only 12 % as compared with ordinary steel.

The tests were over a period of two years and were carried out with rails 130 lb. per yard, rolled by the Bethlehem Steel Company, carbon content 0.7 %.

On four other railways, after taking very careful measurements, covering about one years traffic, an increased life of about 90 % was shewn in favour of rails treated by the Sandberg process as compared with non-treated rails.

At the present time about fifty railway companies, in different parts of the world, are carrying out trials to test the wearing qualities of Sandberg sorbitic rails and tyres.

The sorbitic micro-structure combines great toughness with great hardness. It is consequently an ideal structure for rails.

The use of higher carbon content steel or the use of rails of an increased weight are less favourable means of solving the problem, because in the first case increase of hardness is accompanied by loss of toughness, and in the second, increase of the area of the tread is not accompanied by a corresponding increase in the areas of contact.

A sorbitic structure has always been sought after in the case of springs where a high elastic limit, to prevent permanent distortion, must be accompanied by adequate toughness to avoid fracture under shocks.

The methods adopted for producing this sorbitic structure in springs (*i. e.*, by drastic quenching, followed by annealing), are not, however, applicable in the case of heavy and cumbersome masses such as rails and tyres.

The Sandberg method of treatment avoids the drastic quenching and its

dangers, but, at the same time, produces the desired sorbitic structure.

Sorbitic tyres made by the Sandberg process are now undergoing severe trials on many railways. A quality of steel being employed which after sorbitic treatment has an elastic limit of over 50 tons per square inch and a tensile strength of over 70 tons per square inch, and which shows a very high standard of toughness under the drop test.

Some preliminary trials with such tyres, on the London Underground Railways, have shewn an increased life of 50 %.

Without an excessive extra price, rails with a Sorbitic structure can be obtained and this structure gives them a greater resistance to wear and to crushing than is the case with rails of ordinary steel.

After several years of trial, the majority of railways will, undoubtedly, adopt the process.

Mr. Willem. (In French.) — When we speak of Sandberg rails, it is understood that we speak of sorbitic steel and not of rails with a high silicon content.

Mr. Sandberg. (In French.) — It is quite certain that Metallurgists and Engineers alike, to-day, are convinced that in order to obtain a solid ingot, silicon must be added, but in order to avoid the formation of a pipe, the ingots should be cast under proper conditions and an adequate discard taken.

In the Spring of 1914, a report was presented to the Institute of Civil Engineers, in London, showing the results obtained with the Sandberg silicon rail. Different trials have been made which have all succeeded with the exception of two. In these two cases, the Engineers had made their trials on 100 tons rails only and had found the wear to be 1/64 inch. On the other lines where these rails were in service, it was found, on the contrary, that on 100 000 tons of rails there was at least 40 % increased life. In this connection, I would remind you of the following.

In 1865, the replacement of steel rails for iron rails was advocated. Trials with steel rails had been made. A report was read before the Institution of Civil Engineers, in London, where it was discussed during seven meetings. It was not until ten years afterwards that the Engineers were convinced that it was preferable to adopt steel rails!

In the same way, ten years have passed before manganese steel was adopted and further, it has taken ten years to convince engineers and metallurgists that the introduction of silicon in steel is highly beneficial.

It is interesting to know that in recent specifications, where there is a question of introducing silicon into steel, a proportion of 0.3 % is specified.

Mr. Willem. (In French.) — 0.3 cannot be looked upon as a high silicon steel. This amount of silicon is simply a deoxidiser, it is, if I may put it that way, a purger of the material and not a special constituent.

At one time 0.6 and even 0.7 % of silicon was common, but this is not so today.

The President. (In French.) — What did metallurgists think of this proportion of silicon? Are not their ideas as regards price too high? Could you inform us what is the difference in price between the rail made of silicon steel and that of the ordinary steel?

Mr. Sandberg. (In French.) — The silicon rail costs about 10 sh. per ton more. As Mr. Willem has just said, silicon has a de-oxydizing effect, but it is clear that

in the case of certain steels, more especially Thomas steel and Bessemer steel, the original additions should exceed 0.3 % in order that this percentage may be retained in the steel. Similar additions are, of course, necessary in the case of Martin steel.

Mr. Willem. (In French.) — Metallurgists were more or less opposed to the introduction of silicon because it caused additional work in steel manufacture.

The President. (In French.) — The exchange of views which has taken place is undoubtedly extremely interesting, but the question is a new one, and the Congress will no doubt be of opinion that it cannot at the present time formulate definite conclusions.

I call upon Mr. Mesnager, who wishes to make a communication on the subject of cracks which appear on the surface of rails.

Mr. Mesnager, *special reporter,* dealt with the question treated on page 88 of his report to the Congress under the title of « Problems to be solved » [1].

Mr. Couvreux, French Midi Railway. (In French.) — We attribute the presence of the cracks to another cause, namely, the cold rolling of the top surface of the rails by the tyres. This mechanical action causes a hammer hardening of a very thin layer of the metal, which loses its elasticity, and in this way cracks are produced.

Mr. Mesnager. (In French.) — What Mr. Couvreux says is correct, and we all know that hammer hardened metal has a lower elongation before rupture than metal not so hardened.

Mr. Couvreux. (In French.) — That explains why the rail of soft steel cracks similarly to that of hard steel.

Mr. Sandberg. (In French.) — We have carried out drop tests on a rail which had broken in the track and we have confirmed the points which Mr. Mesnager has just mentioned.

After placing the rail with the head down, the blows were given and the rail broke in three or four pieces. The cracks were 6 to 7 mm. (1/4 to 9/32 in.) in depth.

We wished to ascertain whether by employing manganese steel the production of these cracks could be deferred. Tests were carried out on a piece of steel used for brake blocks and we found cracks 6 to 7 mm. in depth in precisely the same way as if ordinary steel had been used.

The important thing is for engineers to ascertain if rails are present in the track which on account of microscopic cracks are liable to break. Up to the present it has only been possible to determine this by lifting the rail and having recourse to laboratory tests as I have indicated. (*The speaker submitted to the meeting a series of photographs of rails that were broken in service.*)

The President. (In French.) — Mr. Sandberg's communication leads me to ask Mr. Mesnager if his observations related to manganese steel rails or exclusively to rails of the old type?

Mr. Mesnager. (In French.) — Generally in the laboratory they had examined plain carbon steels. I may, however, point out that cracked solid crossings of manganese steel had been put in the press in the laboratory, and we were very much astonished that the cracks did not extend like those in carbon steel. Certain crossings in which cracks had been noticed were kept in service on secondary lines and answered well, the cracks not apparently extending.

[1] See *Bulletin of the International Railway Association*, number for December 1921, p. 2032.

As regards carbon steel rails, it would be very interesting to discover some process by which the depth of the cracks could be estimated when the rail is in position. These shallow surface cracks are found to have a depth of only a fraction of a millimetre and appear to offer no serious inconvenience, on the other hand, cracks have been found 10, 15 and 20 mm. (3/8, 19/32 and 25/32 in.) deep. From the photographs that have been passed round, you will have seen that certain of these flaws reach a depth of 25 mm. (1 inch).

It is by no means rare, when test pieces taken from these rails are submitted to a drop test, to find at the place where they break, black oxydised flaws, which often have a depth of 10 to 15 mm. (3/8 to 19/32 inch). It is these flaws, deep and dangerous, which we should be able to discover when the rail is in service.

A method of doing so, however, has not yet been found, though it is evident that it would constitute a considerable advance in progress, as it would ensure of rails being scrapped which are dangerous to be in service.

The President. (In French.) — If no one else desires to speak, I will declare the discussion closed, and propose to adjourn till Monday morning. (*Agreed to.*)

Meeting held on 24 Avril 1922 (morning).

Mr. BRUNEEL, IN THE CHAIR.

Mr. Depoorter. *secretary*, read the official report of the discussion which had taken place on question III.

— This official report was adopted.

Mr. Mesnager, *special reporter*, read the summary of the discussion.

The report was arranged as follows :

« The 1st section then agreed to the following summary :

« 1° Cast manganese steel with 12 % of manganese and 1.3 % of carbon gives excellent results and is economical for use in crossings. It is especially so in crossings cast in one piece. It is also advantageous for rails on curves of small radii in cases where the traffic is dense and the speed low;

« 2° Opinion is not unanimous with regard to the use of other special steels. The superiority of any one of these is not universally acknowledged;

« 3° Tempering rails is favoured by a few engineers; the majority are against this practice, except in cases where a sorbitic structure is desired;

« 4° It is desirable that experiments be continued to ascertain what are the best conditions for the use of manganese steel, also to determine the actual value of other special steels and the best conditions for their use, as well as to determine the causes of the failure of rails in service. »

The President. (In French.) — We are all unanimous in acknowledging the remarkable accuracy with which this summary has been prepared by Mr. Mesnager. (*Applause.*)

— I declare that it be adopted.

DISCUSSION AT THE GENERAL MEETING

Meeting held on 26 April 1922 (afternoon).

Mr. R. DE CORNÈ, HONORARY VICE-PRESIDENT, IN THE CHAIR.
GENERAL SECRETARIES : Mr. J. VERDEYEN ; Mr. E. FRANZA ; Sir HENRY FOWLER.
ASSISTANT GENERAL SECRETARY : Mr. N. GIOVENE.

Sir Henry Fowler, *general secretary*, reads the

Report of the 1st section.

(See *Daily Journal of the session*, No. 9, p. 6).

« The discussion was opened on question III which dealt with Special Steels. Mr. MESNAGER (*special reporter*) spoke as follows :

« In the remarkable report of Mr. Cushing, full of interesting information, he calls attention to the conclusion of the Congress of 1900, in which it is pointed out that anything which will help the question of the gap in the crossings or frog will be of the greatest benefit. At that time the weight on a locomotive axle never exceeded 25 tons or on a wagon axle 18 tons. But now it has been recognised that the increase in loads (to 30 tons and then 33 tons) and in the speed over crossings has altered the problem, and one has now to turn to special metals for crossings, etc. In 1910 Mr. Besler (*reporter for America*) suggested at the Berne Congress that rigid crossings should be of manganese steel. This suggestion was turned down by the section, but the question of the metal for crossings was kept on the programme by the full meeting.

« Mr. Cushing pointed out that manganese steel was invented by Hadfield in 1887, and that the first crossing of this metal was placed on a steam railway in 1900 at a point where the speed was slow.

« In what follows — Mr. MESNAGER said — I will speak not only of the United States of America, but of other countries in order not to go over the same ground several times.

« *Characteristics.* — Manganese steel is characterised by its strength and resistance to wear. Generally its composition is :

« Manganese	10 to 14 %.
« Carbon.	1.3 %.
« Phosphorus	Under 0.1 %.
« Silicon.	From 0.30 to 0.90 %.

« The manganese contents is limited by the price of that element, which before the war was obtained from Russia and India and today comes — at all events for America from Brazil, Cuba, Central America and the United States.

« By a proper heat treatment — tempered at 900° C. (1 652° F.) the cementite is transformed into austenite, more ductile and more capable of resisting wear. The metal then has the following physical characteristics :

« Elastic limit . . .	19 to 38	English tons per square inch.
« Ultimate strength.	44 ½ to 74	English tons per square inch.
« Elongation	15 to 45 %.	

« When rolled it usually contains less phosphorus and silicon, and is stronger than cast metal. In this state it does not usually fall below :

« Elastic limit : tons per square inch.
America . 28 $^1/_2$ | France. . . . 60

« Ultimate strength : tons per square inch.
America . . 52 | France . . . 57

« Elongation : 15 to 45 %.

« One of the great difficulties with it is that it has a shrinkage of 2.6 % in casting.

« At present it has chiefly been used for crossings and other fixed apparatus of the permanent way.

« In America it is stated that it is economical to use this steel where ordinary apparatus wears out in twenty months. The price is double, but the life is six times as great. As a result of the information supplied by the American Companies it may be said that they are in agreement *that manganese steel is satisfactory and economical at points where the service is heavy and the trains numerous.*

« *Rails.* — Beside its principal employment on crossings built up of rails or in a single piece, it has been used for rails on curves of small radius where the wear has been very great, and on rails where the speed is low, such as Metropolitan Tube Railways. It has the objection of being difficult to cut to length or where it is necessary to machine it at the joints.

« *Check rails.* — It is now used on a very large scale in America. In Algiers it is employed for the sliding portions of expansion apparatus.

« With regard to other special steels, the information which has been received is contrary and inconclusive.

« In every case it would seem that the use of high tensile carbon steel gives only moderate results, and leads to frequent fractures.

« Only Sandberg treated steel, which has a sorbitic microstructure would seem to be of interest : « the results so far are sufficiently favourable to continue the trials ». Mr. Sandberg, who is present at this meeting, would be able to complete the information given by Mr. Cushing of results which have been obtained since the publication of the report.

« Mr. Mesnager afterwards read conclusions of the report from Mr. Cushing, and added that the information received by Mr. Sand (*reporter*) showed that on several of the Spanish lines all the crossings were made of manganese steel.

« In France, the Paris-Orleans Railway, after a series of trials which commenced in 1906, decided to replace all the crossings on their main lines with this metal.

« The Metropolitan Railway in Paris are equally satisfied with the employment of crossings made of manganese steel — they found it advantageous and also decidedly economical.

« Other special steels are stated to be advantageous under particular circumstances, but one cannot yet say for any one of them that everyone is in accord as to the conditions where they may be employed with advantage. They are in fact not yet beyond the experimental stage.

« It is desirable that this question should continue to receive attention, it being possible that several special steels will show within a short period a decided superiority for particular applications.

« The President proposed to limit the discussion to particular points without entering into the details of the manufacture of the special steels. He asked in the first place for information with regard to specifications of manganese steel imposed by the companies which used it.

« Mr. Jullien (*Paris-Orleans Railway*) replied that the French Companies had not prepared a regular specification, but they dealt with manufacturers in whom they had every confidence to supply what was required. He asked the delegates representing English speaking countries to give information on the following points :

« 1° Has the introduction of manganese steel caused the use of spring crossings to be abandoned?

« 2° Does one in England pay a price for manganese steel three times in excess of that for ordinary steel? In France the price is only double;

« 3° In America do they fit the manganese steel crossings for re-use in simply grinding them, or do they first of all put them in a press with a view to making them exactly the right shape?

« 4° Are rolling mills for manganese steel rails yet in working in England?

« Mr. Cooper (*City & South London Railway*) stated that is company always used spring crossings. He went on to say that during the twenty or so years they had employed manganese steels, they had obtained very favourable results, and a great economy as compared with ordinary steel. The general life of apparatus made in manganese steel is from six to ten times as long as that obtained from ordinary steel. With regard to the cost, Mr. Cooper was only able to give pre-war figures, — manganese steel cost £27 per ton as compared with £7 per ton for ordinary steel or about four times as much.

« Manganese steel rails are used on curves of small radius on lines where the traffic is intense, and the wear very great. In order to give an idea of the great durability of manganese steel rails, he stated that at places where ordinary steel rails were worn out in twelve months, they substituted five years ago manganese steel rails which were still in service, and from which they hoped to get three more years wear. The increase of life is therefore in the proportion of 1 to 8.

« On very sharp curves (5 chains), it has been found that rails are scraped, not because of their loss of weight, but owing to their having become corrugated.

« The same may be said of the sorbitic rails used on the District Railway which had otherwise given satisfactory results, but have been taken out of service for the same reason. The advantage of sorbitic steel should be from 80 tot 90 %, but this is reduced to 40 % as they also had to be withdrawn owing to corrugation.

« Mr. de Boulongne (*Paris, Lyons & Mediterranean Railway*) thought that it ought to be more advantageous to employ apparatus cast in a single piece than to use crossings built up of rails, and asked for information from engineers who had employed this method.

« Mr. Jullien stated that before the war the Paris-Orleans Railway only used apparatus built up of ordinary steel, but owing to the difficulty of procuring this, the Company, since the armistice, had used apparatus cast in one piece of manganese steel, and had not ordered any other.

« Mr. Cambournac (*Northern Railway of France*) stated he did not follow any absolute rule, and that under certain circumstances, as on curves, the use of cast apparatus which could not be « set », as required, presented difficulties. On the other hand the use of apparatus of manganese steel, either cast or built-up, was of great interest on lines with dense traffic, but because of its high price it did not offer the same advantages on lines where the traffic is small.

« Mr. Balling (*Paris-Orleans Railway*)

stated that he was in agreement with those last points. The Paris-Orleans Company at present only ordered apparatus of manganese steel for their main lines; apparatus of the old type was taken out and used for repair work on less important lines where it would last for many years.

« Mr. Cooper said he had obtained excellent results with cast apparatus, but agreed that this was chiefly on points where the speed is low (this is notably the case on the District Railway). His experience was that apparatus built-up of rails works best where the speed over points is great.

« Mr. Willem (*Belgian State Railway*) spoke of the utilisation of crossings of manganese steel for light railways where, owing to local conditions, apparatus of ordinary steel was found to give bad results from a maintenance stand-point.

« The prohibitive price of manganese steel however limited its employment, and it would be of interest to fix proper specifications for reception.

« Mr. Schrafl (*reporter speaking in the place of Mr. Sand, deceased*) stated that crossings of manganese steel cast in one piece had been on trial since 1910 at points where the traffic is dense, and had given very good results; and still after twelve years use it was not possible to fix their future life, even approximately. These crossings had however two grave defects, *e. g.*, as manganese steel could not be drilled it was necessary to have special fishplates closely fixed to keep the crossings in position, and if one of these broke it was difficult to replace it as quickly as necessary. The second point is that in Switzerland these crossings are very costly, much more so in fact than the price the French Railways say they are paying for them, therefore, except for certain exceptional cases, this high cost made their use prohibitive.

« Manganese steel is at the same time ductile, strong and very hard, and offers a great resistance to wear.

« These qualities however are not indispensable for all parts of a crossing. They are only really useful at the portions which are subjected to shock and friction.

« Bearing these latter points in mind, manganese steel used only in those portions of the apparatus renders it as durable as cast steel crossings, with very much less cost and would allow of the use of normal fishplates for connection with the other portions.

« In addition to this for several years we had fitted manganese steel plates to the wing rail of a certain number of crossings at the point where the tyre passes over the wing rail. The crossings of built up rails which have been fitted in this manner, and of which ten were put into position in 1912 in the sidings to the entrance to the stations, are perfectly intact at the present day. This system has shown that the employment of insertion plates of manganese steel in crossings ought to be much more frequently used in Switzerland, and this would have been done so if the war and the economy which has resulted from it, had not imposed such stringent regulations with regard to expenditure on repairs. Undoubtedly when circumstances are more propitious recourse will be had to this method.

« Mr. de Boulongne asked Mr. Cooper if his remarks with regard to the premature scrapping of cast steel apparatus, which was attributable to a defect in workmanship, applied to recently constructed apparatus.

« Mr. Cooper replied that the actual

workmanship with manganese steel and with apparatus of ordinary cast steel was good.

« The discussion was then opened on the employment of steel with a sorbitic microstructure as given by the Sandberg process.

« Mr. Cambournac asked whether sorbitic treated rails were employed, and if the price is lower than for manganese steel rails and also he wished to know where they are employed.

« Mr. Sandberg (*Chinese Government*) said that in all cases where points and crossings have only a life of four or five years he strongly recommended the employment of manganese steel.

« The employment of Sandberg sorbitic steel for crossings, etc., will give results very superior to those attained with ordinary steel, in that they offer much greater resistance to wear and crushing.

« Since the time when Mr. Cushing wrote his report, the results obtained from the « Turkey Hill Curve » of the Pennsylvania had been published by Mr. Shand (chief engineer) who had kindly given the complete results to Mr. Sandberg, and had given him authority to quote them.

« These showed that rails of Sandberg sorbitic steel had increased the life by 85 %, whilst the extra cost of the work was only 12 % above that of ordinary steel.

« These experiments covered a period of two years, and were carried out on rails weighing 130 lb. per yard, which were rolled by the Bethlehem Steel Company from steel having 0.7 % of carbon.

« The « Boston Elevated Railway » had found that Sandberg rails gave a life twice that of ordinary carbon steel rails. Actually about fifty railway companies in different parts of the world are making experiments with rails and tyres manufactured by the Sandberg process. As the sorbitic microstructure is combined with more ductility in the main body of the rail, it is an ideal material for such purposes.

« The use of higher carbon contents steel or increasing the weight of the rails is a less favourable means of solving the problem.

« Springs, which ought to have the highest possible elastic limit to resist shock, ought also to be treated so as to give a sorbitic structure.

« Without a great increase in weight, one is able to have rails with a sorbitic structure, which allows them to acquire much greater resistance to wear and crushing than is the case with ordinary steel rails. Within any years the trials on railways, which at present are being carried out, will be probably completed.

« A discussion took place between Mr. Willem and Mr. Sandberg as to the proper proportion of silicon, and the effect it had on deoxidising the steel.

« M. Mesnager read a note on the production of cracks on the surface of rails. He mentioned a method of producing these cracks experimentally by heating the surface of the rail to a « straw » heat, the body of the rail being kept in water, which was the condition he believed they were subjected to when the wheels were locked by the brake and skidded along the rails. He stated that one ought to submit steels to laboratory experiment to ascertain if they are likely to crack.

« Mr. Sandberg said that the very interesting remarks of Mr. Mesnager on the microscopical cracks on the worn surface of rails confirmed his opinion of the serious consequences which might result from these.

« He read a note on the interesting conference of the « Institution of Civil Engineers » which was held in June 1921, at which he reported the case of some rails which had broken into several pieces through this cause.

« The President then called upon Mr. Mesnager who, on the result of the discussion, had drawn up the following summary on the subject. »

The President. (In French.) — This is the

Final summary.

« 1° Cast manganese steel with 12 % of « manganese and 1.3 % of carbon gives « excellent results and is economical for « use in crossings. It is especially so in « crossings cast in one piece. It is also « advantageous for rails on curves of « small radii in cases where the traffic « is dense and the speed low;

« 2° Opinion is not unanimous with « regard to the use of other special steels. « The superiority of any one of these is « not universally acknowledged;

« 3° Tempering rails is favoured by a « few engineers; the majority are against « this practice, except in cases where a « sorbitic structure is desired;

« 4° It is desirable that experiments be « continued to ascertain what are the best « conditions for the use of manganese « steel, also to determine the actual value « of other special steels and the best con- « ditions for their use, as well as to deter- « mine the causes of the failure of rails « in service. »

— The general meeting ratified this summary.

Motion.

Mr. Giovene, Italian State Railways. (In French.) — As regards question III, I have prepared a motion proposing that the investigation of the use of special steels be carried forward to the programme of the next Congress. A proposal of this kind, however, could not be presented by the first section alone, because it would exceed the limit of its powers and belongs partly to the province of the 2nd section. That is why, on the advice of the President of the 1st section, I am arranging to put this motion forward at the general meeting.

The question of special steels has lately risen to be one of first importance in all technical matters in which railways are concerned, not only for fixed material, but also for the rolling stock, so that it is equally a matter of interest for the 2nd section.

So as not to weary the meeting, I will limit myself to simply reading my proposal :

« The question of special steels has been the object, at this Congress, of three very interesting reports which Mr. Mesnager has summarised with great clearness and moderation. The conclusions reached are definite as regards manganese steel and on the tempering of rails. With regard to the use of other special steels, the reporters appreciate the need to continue the investigations with the object of determining the exact conditions which necessitate the use of special steels, of improving their manufacture, and of ascertaining their relative value and the conditions under which they should be used.

« This lays down a programme which the Association ought not to neglect. It ought to be agreed to so that at the next Congress one ought to be able to discuss fully the question of the use of special steels on railways from every point of view, that is to say, its use in all metallic structures, and above all for use in connection with bridges and rolling stock.

« With regard to this last point, it is unnecessary to call attention to the especial suitability of these steels for the parts of mechanism which are subjected to high stresses, whether alternating or centrifugal, which parts may by this means be made lighter and therefore easier on the permanent way.

« I propose the following resolution :

« The Congress having noted the in-« terest taken in the question of the use « of special steels in all technical rail-« way work, that is to say, for permanent « way (fixed materials) for metal struc-« tures and for rolling stock, express the « view that the two following questions « should be included in the programme « for the next session of the Congress « and should be discussed at that Con-« gress :

« 1° The use of special steels for per-« manent way (fixed materials) and for « metal structures, especially for bridges, « with the object of reducing their « weight and so allowing of the solution « of problems which it is impossible « when ordinary steels are used;

« 2° The use of special steels for roll-« ing stock, and especially for certain « parts of steam locomotives and electric « locomotives, with the object of streng-« thening the parts subjected to high « stresses without increasing their di-« mensions and decreasing the weight of « parts subjected to alternating or centri-« fugal movement and consequently di-« minishing the injurious effects they « have on the permanent way. »

Mr. Gioppo, Italian State Railway. (In French.) — Remarked that the question of special steels for railway bridges had already been dealt with at the session in Milan in 1887, and that they had since always adhered to the recommendations made at the session as regards the manufacture and use of special steels.

In my opinion it is not necessary to return to this part of the subject by adding it to that of special steels for locomotives and rails. If it is definitely decided to make it figure on the programme, it ought to be as a separate subject.

Mr. Giovene. (In French.) — It is true that the question of special steels for bridges has already been considered at a previous session, it is also true, however, that in late years very important progress has been made in this direction, and we may safely say that in the use of special steels, quite a new world has arisen.

In America, for instance, numerous constructions had been made and schemes got out to utilise the characteristics of each class of steel, and it is precisely on account of the most recent of these schemes that I made my proposal in which bridges form part, and not in order to return to the subject as discussed thirty-five years ago.

The President. (In French.) — It appears to me that the motion, as put forward by Mr. Giovene, is not in contradiction to the statement made by Mr. Gioppo.

It is a motion of a general character; I am therefore of opinion that, though the question was discussed at a previous session, it is still open to be examined and completed in general terms, as Mr. Giovene proposes.

As no one else wishes to make any further remarks, I put Mr. Giovene's motion to the meeting.

— This motion was adopted by the general meeting, and on account of its comprehensive character, was remitted to the Permanent Commission to be placed on the programme of the next session.

624 .63 & 721 .9]

QUESTION IV

REINFORCED CONCRETE.

Use of ordinary concrete and of reinforced concrete on railways.

Preliminary documents.

1st report (all countries, except Denmark, Sweden, Norway, Holland, Great Britain and America), by Mr. M. CASTIAU. (See English edition of the *Bulletin* of February 1921, p. 99, or separate issue [with red cover] No. 12.)

2nd report (Holland), by Mr. C. LEEMANS. (See English edition of the *Bulletin* of January 1921, p. 3, or separate issue [with red cover] No. 11.)

1st supplement to the 2nd report, by Mr. C. LEEMANS. (See English edition of the *Bulletin* of August 1921, p. 1108, or separate issue [with red cover] No. 27.)

2nd supplement to the 2nd report, by Mr. C. LEEMANS. (See English edition of the *Bulletin* of February 1922, p. 347, or separate issue [with red cover] No. 59.)

3rd report (America), by Mr. C. H. CARTLIDGE. (See English edition of the *Bulletin* of December 1920, p. 815, or separate issue [with red cover] No. 10.)

4th report (America), by Mr. G. A. HAGGANDER. (See English edition of the *Bulletin* of July 1921, p. 743, or separate issue [with red cover] No. 19.)

5th report (Great Britain), by Mr. W. W. GRIERSON. (See English edition of the *Bulletin* of July 1921, p. 761, or separate issue [with red cover] No. 19.)

6th report (all countries, except Denmark, Norway, Sweden, Holland, Great Britain and America), by Mr. A. L. GOLARD. (See English edition of the *Bulletin* of November 1921, p. 1851, or separate issue [with red cover] No. 42.)

7th report (Denmark, Norway and Sweden), by Mr. P. M. BÜLOW. (See English edition of the *Bulletin* of January 1922, p. 25, or separate issue [with red cover] No. 51.)

Special reporter : Mr. W. W. GRIERSON. (See English edition of the *Bulletin* of April 1922, p. 643.)

SECTIONAL DISCUSSION

Meeting held on 25 April 1922 (morning).

Mr. BRUNEEL, IN THE CHAIR.

Mr. Grierson, *special reporter*, reads his summary of the various replies that had been prepared on the subject of question IV. This summary has been published in the English edition of the *Bulletin* of April 1922.

He proceeds as follows :

The papers contributed on question IV are very complete, and I must apologise if, in a necessarily restricted summary, points may have been omitted to which individual authors may attach special importance, but if this be the case, I hope they will correct any such omissions during the discussion.

A perusal of the papers submitted, clearly indicates that reinforced concrete has been used to a considerably less extent in Great Britain and the Overseas Dominions than on the Continent and in America, and this undoubted fact raises a question of interest, not only to my British colleagues, but also to the delegates present from the other countries in Europe and America, as to whether the cause is to be attributed to excessive caution, or to a justifiable doubt as to whether the qualities of the material and its future behaviour have been sufficiently fully demonstrated, and these are points on which I hope delegates will express their views during the discussion.

While it is a matter of universal admission that concrete, both ordinary and reinforced, are materials of great value for railway purposes, I am satisfied that an individual engineer would not be correct in assuming that, because it had been found advantageous to use the materials in one country, or even in a particular district of his own country, it would necessarily be advantageous to use the materials in the particular district in which he was interested, so much depending on local geological and manufacturing conditions, and the question of transport and, therefore, cost.

There is another point to which I would like to draw special attention, *viz.*, the desirability of allowing a full margin of safety in calculating the stresses to which a structure is exposed and in designing accordingly the various members. It is well known that it is not possible to depend that a finished mass of concrete will have the same relative unit strength as indicated by experiments carried out in a laboratory, the results of tests frequently varying greatly, even when made by the same person and with the same materials.

Further, a slight fault in the execution of the work on the ground, difficult to detect, may seriously weaken the strength of any particular member, and consequently the whole structure.

In Great Britain it is customary to invite constructional ferro-concrete engineers to submit designs, and undoubtedly, there is sometimes a disposition to submit a light, and therefore cheap, design as an inducement to its acceptance. I am of opinion that all railway engineers should make a point of calculating the stresses in their own offices, and carefully checking designs submitted, and every paper emphasises the necessity of employing experienced and trained inspectors to closely supervise the work upon the ground.

In regard to cost, it is not possible to lay down any general statement that the use of ferro-concrete for a given structure will prove more, or less, expensive than some other material, so much depending upon the locality, and the character of the intended structure. Undoubtedly, however, in many cases, considerable economy results from its use.

As to the life of the material, sufficient time has not elapsed to enable any definite pronouncement to be made, but, in the case of a well-designed and built structure, it should certainly be longer than that of steel. I do not think, however, that the most enthusiastic supporter of reinforced concrete, who has examined the masonry and brickwork

buildings, two thousand years of age, to be seen in this City, would be sanguine enough to hope that reinforced concrete will have an equal life.

The President. (In French.) — I declare the discussion open and call upon Mr. Mesnager to speak.

Mr. Mesnager, French Government. (In French.) — From the remarks made by Mr. Grierson, it would appear that doubts were thrown on the reliability of laboratory tests. Now everything depends on how these tests are made.

In France, to secure conclusive results, blocks of concrete are made at the works and it is from experiments made in the laboratory on these blocks that the strength of the structures is determined. In some cases pieces are actually cut from the structure itself and sent to the laboratory; such specimens are chosen at random and the contractor can have no idea from which part they will be taken.

Under conditions such as these there can be no doubt as to the reliability of the laboratory tests.

I am also astonished that concrete is blamed because its resistance is doubtful; for nothing can be easier than to make tests which will check the strength : it being only necessary to send test pieces to two different laboratories, unknown to each other, and to compare the results.

With regard to the durability of concrete the Roman buildings show how little fear we should have on these grounds and the vicinity of the ruins of ancient Rome is hardly the place in which to accuse concrete of lack of durability.

With regard to the question of impact, I recognise the advisability of making further experiments on account of the increase in the weight of the locomotives. The Continental regulations are older than those in force in England : the important point is that the regulations in each country should be sufficiently severe to prevent carelessness.

So long as a reasonable stress is not exceeded there should be no fear of accidents. When accidents had occurred in France this had always been found to be due to a breach of the regulations by the contractor. Even cracks were usually the effect of carelessness, omission to allow for contraction due to cold, or failure to allow for shearing stresses.

The President. (In French.) — Mr. Séjourné wishes to speak immediately on the subject of « ciment fondu » (melted cement) as he has to leave the meeting at 11.30, I therefore request him to put forward his views.

Mr. Séjourné, Algerian Section of the Paris, Lyons and Mediterranean Railway (In French.) — I wish to point out to the section that we have used « ciment fondu » in structures on the Nice-Coni line on which serious trouble had occurred, not through the use of bad cement, but because the cement had been attacked by water containing sulphates.

The cement that had previously been used had stood well in a tunnel on this line, but had deteriorated in other structures. Serious failures have occurred which will cost from 800 000 to 900 000 francs to repair.

Since 1916 all known cements have been tried. Up to the time of the meeting, the « ciment fondu » mixed with any kind of sand has shown itself proof against the action of water containing sulphates, some of these sands containing up to 50 % of crushed anhydrite.

As the result of these trials « ciment fondu » has been used exclusively in all structures exposed to the action of water containing sulphates.

The President. (In French.) — As the question of « ciment fondu » has been raised, I will request Mr. Mesnager to give the characteristic properties of this cement and its cost as compared with that of other cements.

Mr. Mesnager. (In French.) — « Ciment fondu » was invented about 1905 by Mr. Bied, then engineer to the firm of Pavin de Lafarge at Teil.

This cement has as its basis calcium aluminate, whereas in ordinary portland cement the basis is calcium silicate. Its composition therefore resembles that of quick-setting cements, but it is burnt at a much higher temperature and contains less inert matter. Ordinary quick-setting cement is usually subjected to a temperature of only 1 832° F. whereas in the case of « ciment fondu » this is raised to 2 732° F., a temperature that causes it to liquefy (hence its name) and ensures complete combination. As silicate replaces alumina at temperatures below this, it is essential that only a small proportion of silica be present in the furnace, otherwise portland cement will be formed as an impurity. It has therefore been necessary to have recourse to raw materials containing, as far as possible, lime only (from limestone) and alumina (from bauxite). « Ciment fondu » differs essentially from ordinary commercial quick-setting cement in that it contains hardly any foreign matter.

By subjecting it to a special treatment (resulting in the formation of a hydrated skin on the particles) it has been made possible to delay the commencement of the process of setting to that required by portland cement : consequently it can be used on works under the same conditions as portland cement.

When, however, the setting has actually commenced the hardening proceeds rapidly. The strength of concrete and mortar made with « ciment fondu » is, after three days, equal to that of concrete and mortar made with portland cement after six weeks. The shuttering can therefore be removed much earlier, and piles can be driven when only three days old.

After three months the strength increases to double that of portland cement concrete, and this enables the size of the scantlings to be reduced for concrete and reinforced concrete. The adhesion to steel is increased practically in proportion to the increased strength of this type of concrete.

Tests have shown that the crushing strength of cubes 8 inches in length of edge, increased continuously. A reduction in strength has been noticed in small 8 shaped tension pieces, but the same phenomenon has been observed with other cements that give excellent results in practice.

The only disadvantage of « ciment fondu » is its high price the cost being more than twice that of portland cement. This is due to the high temperature of the burning and to the use of bauxite. This disadvantage however is compensated, to some extent, by a reduction in the size of the scantlings and the saving due to the shorter time during which the use of shuttering is required.

Laboratory experiments carried out in Paris, during five years before the war, have proved that this cement could stand the action of sea-water and of waters containing sulphates of calcium and magnesium. The results have been confirmed by the experiments made in Mr. Séjourné's department since 1916, the result of which have been that for a time he has purchased the whole output of the Teil works.

I conclude from this that the strength

of « ciment fondu » is double that of other cements.

In all those countries where the waters are charged with sulphates as in Algeria, Spain, and even in some parts of Italy : the use of « ciment fondu » might prove of great value. (*Applause.*)

Mr. Bülow, *reporter*. (In French.) — I must apologize for the difficulty I find, as a Dane, in following the discussion, carried on partly in French and partly in English, because I have not sufficient knowledge of those languages. There are, however some matters to which I desire to draw attention.

Concerning the proportions in which the concrete was mixed I think it important that the concrete should contain sufficient cement and sand to fill the voids in the mass, and it is also necessary that there should be sufficient cement to ensure that the steel should be thoroughly encased in the concrete. The concrete should not, on the other hand, be too rich in cement, seeing that the greater the amount of cement used the greater the tendency of concrete to contract, and that contraction was the cause of cracks forming.

In Denmark all structures of ordinary concrete are usually executed in concrete mixed in the proportions 1 : 3 : 5 (1 of cement to 3 of sand and 5 of broken stone) or in the proportion 1 : 4 : 7. In both cases care is taken to use sufficient mortar to ensure that the voids are properly filled; the mortar however is not itself waterproof.

All structures of reinforced concrete are generally made of concrete mixed in the proportions 1 : 2.5 : 3.5 for internal work such as floors and similar work, but for the exterior the proportions 1 : 2 : 3 are adopted. It is not advisable to use mortar poorer than 1 : 2 for the exterior because it is essential to protect the reinforcement from rusting. In Sweden the proportions 1 : 3 : 4 is still often used for reinforced concrete; this proportion was used formerly in Denmark but has now been abandoned completely.

I wish to add some general remarks relating to reinforced concrete structures.

Reinforced concrete has been extensively used for a long time past on railways and there can be no doubt but that it is a constructional material the value of which no technical man can ignore.

Nevertheless, in my opinion, circumstances have shown that reinforced concrete structures have still certain defects, which have come to light during the last few years, and consequently in some cases, there was hesitation in using it.

In my report I have endeavoured to draw attention to the risk that might arise through building structures — designed on too theoretical a basis — without sufficient attention being paid to the varying conditions prevailing at the works and to the actual methods of execution.

For financial reasons, attempts are often made to reduce the thickness of the concrete and particularly the amount of steel reinforcement, so that if the work is not carried out exactly in accordance with the drawings, or if an error has been made in the workmenship, danger may arise. It has frequently been noticed, particularly in the case of designs executed by contractors and engineers who have not had experience in the works, that the steel rodding is not anchored for a sufficient length into the concrete, and does not overlap for a sufficient length at the joints. The length of overlapping is often only 8 to 12 inches and the consequence is that the strength of the structure is dependent on the way in which the workmanship

has been carried out over this short length. Several examples have been given in my report.

It as also sometimes been found that reinforced concrete structures have been badly designed so as to imperil the safety of the whole by want of proper precautions when resuming building operations after necessary intervals such as from one day to another.

The strength of concrete depends to a great degree on the manner in which it has been prepared and placed in position and — in the case of carelessness during construction — can easily fall to one-half of the figure for compressive strength used in the calculations; similarly, the stresses on the steel can easily rise considerably above those calculated, from no other cause than the defective arrangement of the steel in the scantlings.

The strength of a reinforced concrete structure depends, to a greater extent than does that of any other form of construction, on the excellence of the workmanship which requires constant attention and conscientious work by workmen, foremen and engineers, and it is recognition of this all important feature that has occasionally given rise to apprehension.

Once the work has been completed it becomes impossible to check the execution of the work, and it is only at a later date, when cracks, etc., occur, that the mistakes that have been made are discovered.

I have already carefully explained, in my report, the causes of large variations in the strength of concrete, and I have at the same time pointed out the difficulties that exist in the way of effective inspection of the materials when large deliveries are in question.

I have also pointed out the difficulties met with in ensuring the proper mixing of the concrete. In the greater number of concrete works it is the rule to carry out the work by contract, and the less the care taken over the mixing, and the wetter the concrete, the easier it is to push on the work. For this reason workmen always have a tendency to add more water than necessary, and even the most rigorous inspection has proved ineffectual to check this practice.

There are many sources of danger both in the preparation of the concrete and in moulding the reinforced concrete structures, and if, by chance, a combination of mistakes should occur, the result might be extremely dangerous to the structure. It is in no case certain that the factors of safety (3 to 5), which have been taken as the basis for calculation purposes, hold good in practice.

Having regard to possible variations in the tensile stresses in the reinforcement and in the concrete arising from the special conditions existing on works, it would appear that frequently a sense of proportion was lacking as to the relative importance to be attached to this consideration and that bestowed on theoretical calculations for reinforced concrete structures. As I have already stated, a large amount of time is sacrified to the investigation of whether the strength of concrete is 569 lb. per square inch or a little more — or whether, in some places, round steel bar 23/32 inch could not be replaced by bar of 5/8 inch or 11/16 inch — while the variable conditions associated with the execution of the work have been overlooked, although these latter might render wholly unreliable the theoretical calculation.

Moreover, attempt at economy in reinforcement has often been the cause of trouble, particularly when it involve the use of a large number of different diameters of steel bars in the same structure,

frequently resulting in a large number of mistakes in the execution of the work.

I wish further to draw attention to the fact that, in steel framed structures, economy is not carried to such fine limits and that much greater reliance can be placed on the work being carried out exactly in accordance with the drawings. In a steel structure each detail has to be correctly shown on the drawings otherwise the parts of the structure can not be assembled; on the other hand in reinforced concrete structures the reinforcement is not connected rigidly together, and the round bar and the stirrups can be readily embedded in the concrete even though the steel is not in its proper place, or the bars not correctly bent, and other defects may easily occur.

In designing a reinforced concrete structure, the engineer responsible for the preparation of the drawings has constantly to bear these considerations in mind, and it is necessary that on the working drawings he should draw particular attention to those portions of the structure which require special care in execution in order to ensure the safety of the whole, whether with regard to the placing of the reinforcement, or the procedure for moulding.

I wish to repeat the first remarks I have made : in reinforced concrete structures, more than in structures of any other kind, a large share of the responsibility is transferred to the office of the clerk of works on the site, for it is only when the work is carried out conscientiously and under strict supervision that satisfactory results can be ensured.

If either of the two conditions is absent danger will always exist.

I take this opportunity of remarking also on the danger incurred by submitting the construction of large reinforced concrete structures to public tender, and leaving the design for the execution of the scheme to the contractor himself. Owing to competition, those who tender are tempted to be too bold in their designs and to make false economies; the administration should work out the complete scheme and leave nothing but the execution of the work to the contractor.

With regard to the influence of outside agencies, such as locomotive-smoke, sea-water, water of infiltration, etc., on the durability of concrete, experience appears to have proved that no trace of damage has been found wherever the concrete was solid and well hardened.

If, on the other hand, the concrete is porous, water will filter through it continuously, dissolving the free lime or transforming it in such manner that the concrete is destroyed in course of time.

All reservoirs, tunnel linings, bridges and works of this kind should, therefore, be constructed in water-resisting concrete, or the concrete should be covered with a waterproof coating.

It has often been seen that stalactites have formed in structures subject to infiltration of water, and these were an indication of the commencement of the destruction of the concrete.

The question of the impermeability of concrete (to water, to locomotive-smoke and to other influences) is in my opinion of great importance and doubtless is one of the vital points affecting the future use of reinforced concrete.

I wish to say a word with regard to the formation of cracks and fissures in reinforced concrete structures :

If deterioration directly due to errors in designs were left out of account, as also mistakes in calculation or other errors of this class, the formation of cracks and fissures in the greater number of old rein-

forced concrete structures arise, in my opinion, from insufficient allowance for shrinkage of the concrete after being placed in position, and from expansions due to heat.

A tensile force may, as is well known, become a cause for anxiety in a concrete structure, when the reinforcement provided is not adequate to resist the load; cracks should be avoided by proper technical arrangements, such as a provision of expansion joints, or the use of suitable steel reinforcement.

The formation of cracks is, however, often due to defective execution of the work, and it is certain that, if, on the works, care were taken to use coarse instead of fine sand, to use only a small quantity of water in the preparation of the concrete, to make careful arrangement that after an interval building operations may be resumed without detriment to the work, and finally to avoid too rapid drying of the concrete, the formation of cracks would in most cases be avoided.

Here again the importance of efficient supervision on the works becomes evident.

I do not suppose that either in my report, or in my conclusions, I have brought any new points to light, and it is also possible that I have been rather too severe in some respects, but in these times, when the fashion of using concrete has become almost a craze, it is perhaps as well — while taking full account of the excellent qualities of reinforced concrete — to examine its defects also, and not to lose sight entirely of the older constructional materials : granite, bricks and particularly steel.

The President. (In French.) — It is well known that the field for reinforced concrete is of immense extent and that we can not hope to solve, at the Railway Congress, all the problems that are raised in relation to this material. For this reason I think that the discussion should be kept strictly within limits with a view to economising time.

I propose, therefore, that only the most interesting features be dealt with, and that questions of a purely theoretical character be left alone. It is above all advisable that the results of personal experience may be given; the object of the meeting is mutual exchange of information and it is desirable that we give particulars of the work we have carried out, without omitting to mention any errors that may have been committed.

Speaking as a Belgian, I think that special thanks are due to reinforced concrete, which, in my country, as in other devastated by the war, has been of enormous assistance in the reconstruction of important structures.

Thanks to reinforced concrete it has been possible to commence work on the day after the Armistice, a thing which it would obviously have been impossible to do had it been necessary to go to the metallurgical works, the greater number of which had had their means for production entirely destroyed by the enemy.

Once the drawings had been prepared we were able to commence work, because the materials for concrete construction did not require any special preparation, and were available for use by the contractors.

Thus it was possible, thanks to reinforced concrete, to re-establish traffic very rapidly on a large number of lines that had been destroyed in Belgium.

I wished to give to reinforced concrete the credit that is its due, for it deserves our full recognition. (*Applause.*)

Another interesting point to which I would call your attention has just been mentioned by Mr. Bülow : it is that of

the supervision required in the mixing of concrete and placing it in position, whether reinforced or not. It might be said that concrete was the best and the worst of materials; when well made it was excellent; when badly mixed it was an abomination.

It is very desirable that each member should give the results of his personal experience regarding the limit of spans that have been allowed hitherto in the construction of under bridges run over by express trains, in as much as not much information has so far been forthcoming relating to this question. For my part, some ten years ago, I had « the audacity » to propose flat bridge flooring of 32 ft. 10 in. span, and my management, which was at that time rather nervous, severely « put the screw on me ». (*Laughter.*)

Bridges however of 39 ft. 4 in. span have been constructed elsewhere, and Mr. Deyl has just informed me that in his country they had constructed bridges up to 55 ft. 9 in. span. Another interesting point which requires investigation is the influence of electric traction on the life of structures and of reinforced concrete sleepers; this is important because electric traction is under consideration by all the large railway administrations. It has been thought that, under the action of electrolysis the metals used in the composition of reinforced concrete might become corroded by the return current.

In Belgium we have endeavoured to make concrete sleepers, but have ceased doing so owing to their expense. Apart from large structures concrete is used for flooring, for signal cabins, and for signal posts.

I think that the discussion may be confined to those points that I have just mentioned, but that if some of my colleagues think it advisable to increase the scope of the programme they are quite at liberty to do so.

Mr. Deyl, *vice-president*. (In French.) — I wish to refer to an interesting under bridge of reinforced concrete with an arch of 55 ft. 9 in. span constructed at Pilsen on the Mélan system and also to straight girder railway bridges up to 29 ft. 6 in. span. These structures have given complete satisfaction. (See appendix.)

Mr. de Boulongne, Paris-Lyons & Mediterranean Railway. (In French.) — Mr. Séjourné has referred to « ciment fondu » and its resistance to the chemical action of calcium sulphate. I am entirely in agreement with him (Mr. Séjourné). In his remarks, Mr. Mesnager has drawn attention to the great mechanical strength of « ciment fondu ».

I have had occasion latterly to study the problem of the strength of concrete when considering a question of altering bridges and I have found that silicious cements, prepared in a special manner readily gives a strength equal to that of « ciment fondu ». In defining a cement as quick-setting, I take this to mean that it requires only two or three days to attain appreciable strength; after this period a tensile strength of 213 to 285 lb. per square inch should be obtained. After six months it might be said that the strength was the same for « ciment fondu » and for silicious cement. The former increases in strength more rapidly than the latter, but the strength of the latter continues to increase for a longer period; silicious cements are more thoroughly burnt than ordinary cement; they are manufactured in France in numerous works.

I wish to make a few remarks relating to reinforced concrete.

I have read with a great deal of interest the various reports that have been drawn up on this question; nearly all the authors draw special attention to the trouble that can arise from the use of an excess of water. Mr. Bülow, in particular, has given interesting particulars relating to the weakness of reinforced concrete that has resulted when the quantity of water has been increased to too great an extent.

I think that the Congress, in making its recommendations, should insist particularly on the danger arising from the use of too great a percentage of water, because, as had been justly said, concrete is excellent when well made and abominable when badly made. If it is well mixed, without too much water, and if it is well rammed, it forms a most useful material for construction.

All those who have had to execute work in concrete have had experience, I would not say of intentional scamping by contractors, but rather of their carelessness. It is evident that very wet concrete can be run more easily, but the results obtained are very much better when the concrete is mixed with its proper proportion of water and care is taken to ram it thoroughly; ramming, however, is an expense which contractors, if they can, are glad to avoid. For this reason it is necessary to state clearly in our recommendations that, if reinforced concrete work is to perform the duties required of it, it must be well made.

I will draw attention to a very interesting structure that has been built on our railway system : namely, a trough bridge which was encased by means of reinforced concrete; with the result that the deflection under load is reduced by one third, indicating consequently a great increase in rigidity.

The track has been run over by heavily loaded trains, and, after ten thousand trains have crossed, the cement when tested with a chisel has been found to be as hard as stone; and the adhesion perfect, but this piece of work had been well executed.

To sum up, it may be said that, when reinforced concrete is well made it withstands all that is required of it, but that when badly made it is absolutely worthless.

The President. (In French.) — This is the universal opinion.

Mr. de Boulongne. (In French.) — We must put this extremely clearly in our recommendations.

Mr. Mesnager. (In French.) — With fine and well burnt cement it is evidently possible to obtain the required strength with sufficient rapidity, but I do not know of any other cement the strength of which increases so rapidly as it does with « ciment fondu ».

I have made piles of « ciment fondu » and others of fine cement produced by the best Swiss works; after three days it was possible to drive the piles of « ciment fondu » with no other damage than slight chipping of the head, whereas the piles of fine cement were broken.

I recognise that fine cement offers a considerable advantage over ordinary cement in the case of structures that have to be erected rapidly, but nevertheless it is inferior to « ciment fondu ».

The President. (In French.) — After what time, according to the regulations, can piles be driven in France?

Mr. Mesnager. (In French.) — Usually they are driven after six weeks.

Moreover, whereas ordinary cement

requires enormous yard space for making the piles, only a small space is required for making piles of « ciment fondu ».

The President. (In French.) — It is time to adjourn, and if you approve we will resume at 3 o'clock. (*This is agreed.*)

Meeting held on 25 April 1922 (afternoon).

Mr. BRUNEEL, IN THE CHAIR.

The President. (In French.) — A question of special interest to railwaymen is the construction of under bridges of reinforced concrete and the limits within which they can be made in practice.

I wish to repeat my desire that those of my colleagues who can give particulars relating to this branch of the subject will do so.

Mr. Lolli, Italian State Railway. (In Italian.) — I noticed in the discussion which took place in the morning that the special reporter and other eminent members of the Congress expressed grave doubts as to the durability of reinforced concrete structures subjected to shocks arising from rolling loads and particularly in the case of under bridges. I think that it might be of interest to know that the Italian railways commenced the construction of bridges of this kind in 1900 and that the number of these structures now exceeds 500. These reinforced concrete bridges are of spans up to 39 ft. 4 in. and 46 feet. I am of course alluding to straight girder bridges. The oldest of these are now twenty-two years old and all are in such condition as to call for no remark. Not one of them has required repair, or strengthening, up to the present.

I have stated that these bridges called for no remark; by this I do not mean to say that some have not shown a few small cracks as is almost inevitable in reinforced concrete and these were probably due to contraction of the concrete in setting; but they were noticed shortly after the construction of the work and have not grown insize and are certainly not connected with the action of the rolling loads. Three or four years ago, I believe about 1917 or 1918, we examined the oldest flat spans to see whether the reinforcement bars had become corroded or had suffered in any way, but the measurements we made did not disclose any trace of reduction in the thickness of the reinforcing bars of these flat arches which had already been at work for sixteen years and upwards. The results of this investigation might help them to conclude that the use of reinforced concrete for large structures on railways is deserving of greater confidence. It is for this reason that I have drawn the attention of the meeting to these results. (*Applause.*)

Mr. Séjourné. (In French.) — Did you find that the steel had rusted where the cracks occured?

Mr. Lolli. (In French.) — No appreciable oxidization of the steel has been found.

Mr. Bauer, French State Railway. (In French.) — In France we have constructed two under bridges in reinforced con-

crete, one in 1910 on the Paris-Dieppe line. This bridge which has a span of 23 feet is situated at a place where the speed attained by the trains is 62 miles per hour. The other bridge was constructed in 1917 over the Sarthe; it consists of four spans each of 16 ft. 5 in. The track, which is actually a branch line, is only used for goods trains running at a speed which does not exceed 22 miles per hour.

Mr. Séjourné. (In French.) — Up to this time no reinforced concrete under bridges have been constructed on the new lines of the Paris, Lyons & Mediterranean Railway.

The President. (In French.) — Have you used reinforced concrete when replacing bridges on the old lines?

Mr. Quinquet, Paris, Lyons & Mediterranean Railway. (In French.) — During the war we used concrete to encase the girders of the superstructure of bridges and interesting results were obtained.

In 1914 we constructed a bridge on a branch line near Moret station over the road that gives access from the town to the station; the municipal authorities agreed to the construction of a pier in the middle of the road, on the undertaking that it would be removed after the war. The bridge was constructed of double T-bars, encased in cement, bearing on the abutments and supported in the centre by the pier. When the war was over they considered the question of whether it was necessary to construct a new bridge or whether, in consequence of the increased stiffening of the steel due to the cement casing, it would not be possible to let the bridge stand and to remove the pier. In order to ascertain this they had used the Manet-Rabut apparatus which enabled them to measure the actual stress on the steel, in the loaded structure. The pier was first reduced in height by a few centimetres so that the girders no longer rested on it. A heavy locomotive was then run on the bridge and the stress in the steel measured; this was found to be quite moderate and the pier was removed entirely. Thus, thanks to the gain in strength of the girders due to the cement reinforcement, girders which had been designed for a given span had been able to be retained for twice the original span, without being subjected to excessive stress by the same locomotives.

As it has become necessary for heavy locomotives to run over lines on which light weight locomotives only previously were used, consideration was given to the question whether the strengthening of the bridges, rather than their replacement would not be effective. They had accordingly experimented with girders cased in cement on a span which had been taken out as being too light to carry modern locomotives; a locomotive was run over and the stress determined by means of the Manet-Rabut apparatus; the girders were then encased, and when the concrete had set, the same locomotive was again run over with the result that the stress in the steel was found to have fallen to less than one-third of its original value.

Fifteen other steel bridges have been encased in the same manner. In general we have found that the stress has fallen to one-third or one-half of its original amount according to the type of structure and its span.

Generally speaking the cost of repairing a bridge by encasing it is lower than that of a new steel bridge.

There is also a further advantage to be gained by encasing the girders; the strength of such bridges is calculated on the basis of the steel alone without taking

account of the extra strength added by the casing; this added strength gives a margin for future possibilities in increased axle-loads.

We are now engaged in making very interesting experiments with the object of saving some cast-iron arch bridges of five openings each of 180 ft. 5 in. span. If it should become necessary to replace each of these spans by steel girders the cost would amount to 5 million francs. We have investigated whether it will be possible to save the bridges by strengthening the cast-iron by an added casing of reinforced concrete and as a result the following proposal has been made to the Bridges and Roads Council.

The lower member is of T-section the rib vertical and the base horizontal; for the carriage of heavy locomotives the flange is short of metal; this deficiency in the cast-iron can not be made up by the addition of cast-iron; the question of strengthening it with steel was next considered. The elasticity of steel being double that of cast-iron it would merely be necessary to replace a given sectional area x of cast-iron by steel of half that sectional area. We were thus led to use bars of steel, rigidly attached to the flange on both sides, and secured rigidly to the arch. Moreover under the load of heavy locomotives the cast-iron of the flanges had cracked and parts had even broken away; for the damaged length the cracked or missing cast-iron was replaced by a second steel bar. Once these steel bars had been fixed it became possible to use them as a basis for reinforced concrete; for this purpose secondary reinforcing bars were put through holes drilled in the web and attached to the large steel bars; these were extended from one member to the next and so on for the whole width of the bridge. They are connected by small steel bars which serve as a skeleton for the cement casing. The lower flanges of the members, which are of too small a section are thus fortified by a slab of reinforced concrete extending over the full width of the bridge and uniting all the members. The strength of this common flange is additional to that of the steel reinforcing bars.

This work is actually in progress and it is not therefore possible to give the results that have been obtained.

Mr. Bülow, *reporter*. (In French.) — There is an error in the table shown on page 647 of the special report (1).

In Denmark we have constructed 300 small rail bridges, but these have abutments of ordinary concrete. The superstructure consists of encased girders, consequently these bridges are not made of reinforced concrete.

We have constructed 12 reinforced concrete under bridges, properly so styled, of 72 ft. 2 in. span.

The President. (In French.) — Are they straight girder bridges?

Mr. Bülow. (In French.) — No, they are of arched form.

In the Scandinavian countries the under bridges are constructed with shorter straight girders and, to minimize the effects of shock, the ballast is laid to the same depth as generally on the track.

Mr. Barrand, *vice-president.* (In French.) — After the armistice I examined two schemes for encased arch bridges that had been constructed in the Lille district for lines carrying heavy trains; I believe I am correct in stating that the span is 82 feet; the speed of the trains ranges up to 75 miles per hour, and I believe that

(1) See the *Bulletin* for April 1922.

my colleagues of the French Northern Railway, whose absence I regret, could confirm that these bridges have proved satisfactory.

The President. (In French.) — I believe that under the pressure of necessity our colleagues of the French Northern Railway have carried this type of construction very far.

Mr. Barrand. (In French.) — The war has been responsible for considerable progress.

The President. (In French.) — We (Belgian State Railways), have also made encased girder bridges, but we have not constructed reinforced concrete straight-girder under bridges for spans greater than 32 ft. 10 in.

Mr. Tintant, French Eastern Railway. (In French.) — I can mention that on a light railway adjacent to our system an arched under bridge of a span exceeding 82 feet has been built.

The President. (In French.) — I must remind the meeting that the question of the possible influence of electric traction on the life of reinforced concrete bridges is also of interest. We know that in towns in the early days of electric traction on tramways, we were accused of causing the corrosion of underground mains; so far as I am aware no cases have been recorded of corrosion of the steel in reinforced concrete.

The next question is that of reinforced concrete sleepers. This has been examined very closely in Belgium because it was impossible to obtain wooden sleepers for a fairly long time after the war. We have not, however, dared to make use of reinforced concrete sleepers for two reasons : first because we have not gained sufficient confidence, and second, because the prices asked were absolutely exorbitant. These went up to 100 fr. per sleeper and even quite recently they would have cost 65 fr., a price which we still consider prohibitive. Moreover, now that the foreign market has been reopened it is possible to obtain wood sleepers for a price of 16 to 17 fr.

I should be glad if our Italian colleagues would give us particulars of what has been done in their country, where concrete sleepers are largely used.

Mr. Barbieri, Italian State Railway. (In French.) — Gives particulars relating to the information given in the report of Mr. Golard and concludes with the remark that the problem has not been solved up to that time.

The President. (In French.) — It may be taken that in those countries where the greatest steps have been taken in trying reinforced concrete sleepers, it is still thought necessary to act with circumspection, and progress is slow because it is felt that they are on difficult ground and faced with uncertain results.

Mr. Balling, Paris-Orleans Railway. (In French.) — On my line trials have been in progress for the last ten years with reinforced concrete sleepers; during the last five years some of these have been laid on sidings and on main lines; but only on those used by slow trains.

These sleepers are of approximately the same shape as wooden sleepers; the characteristic feature is that the screw-spikes do not take hold of the sleeper by means of a wooden block, but by a cast iron sleeve so moulded as to have exactly the same thread as the screw-spike; this sleeve is firmly embedded in the sleeper at the time of manufacture. The upper part is of rounded shape and the lower part square with an enlarge-

ment so that the pressure on the concrete is reduced to a minimum; the sleeve actually takes a bearing on the reinforcement bars.

At present we have six thousand of these sleepers on our railway system; a large number have been laid in the tracks at stations where they are doing excellent work; the others are laid on main lines run over by slow trains; here again they are behaving well. It should be noted that these have not been manufactured in quantities; their construction has been superintended personally by the inventor; the work consequently has been done extremely carefully.

The President. (In French.) — I wish once more to draw attention to the fact that these sleepers are only in use on lines carrying slow traffic.

Mr. Balling. (In French.) — On some of the lines the speed is equal to 37.5 miles per hour.

Mr. Desprets, Belgian State Railway [1]. (In French.) — I wish to draw attention to the fact which has not yet been brought out, that up to the present construction of reinforced concrete sleepers tends to proceed on two distinct lines. The first consists in the construction of reinforced concrete sleepers of prismatic section similar to that of the wooden sleepers; the length of the latest patterns of sleepers of this type, that have been tried on the Italian Railways, is 7 ft. 10 1/2 in.; this is the same length as that of the sleepers undergoing trial on the Paris-Orleans Railway.

If the problem is approached from the mathematical side, this length corresponds to that which gives equal bending moments about the fastenings and the centre of the sleepers. Thus both the railway systems in question obtain the same length of sleeper though considering the question from different points of view.

If we adopt Winkler's hypothesis as applied by Zimmermann, and if we take a constant value for the coefficient of the ballast, we find that this length of 7 ft. 10 1/2 in. corresponds to a ballast of average resistance giving equal values to the moments that I have just mentioned, whereas in wooden sleepers 8 ft. 6 3/8 in. in length, equal deformation is found at the ends and at the centre.

The sleepers which have been tried on the Paris, Lyons and Mediterranean Railway, consist of two reinforced concrete blocks under the rails, connected by metal stays or by reinforced concrete and belong to the second type. They avoid the defect of the old blocks, connected by round steel-bar stays, which cause widening of the gauge owing to excessive rigidity of the stay bars.

The advantage of the Vagneux sleepers is found to be in the fact that the loads are taken almost entirely on the block ends and that the stay is subject to small stresses only. It can not be claimed that the sleepers used on the Paris-Orleans and the Italian State Railways are strong enough to carry the usual axle-loads with the reinforcement that have been allowed, and consequently it does not appear possible to extent their use to main lines without considerable strengthening.

The sleepers of the Paris-Orleans line have steel-bars 11/32 inch in diameter; but to carry the axle-loads of the locomotives running in Belgium, it would be necessary for these bars to be at least 15/32 inch.

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(1) See R. Desprets : « Note on some recent types of reinforced concrete sleepers » (*Bulletin of the International Railway Association*, number for July 1922, p. 959).

Mr. Balling. (In French.) — Under normal conditions the centre of the sleeper has no bearing on the ballast.

Mr. Desprets. (In French.) — This is so when a sleeper is first laid. But do you not think that in course of time it will take a bearing.

Mr. Balling. (In French.) — Under normal conditions of maintenance the centre should not bear.

On the lines for the maintenance of which I am responsible, I have never seen any wooden sleepers that have broken because they were supported in the centre; for this reason all the calculations that have been made have been based on a wrong hypothesis.

Under these conditions I maintain that 13/32 inch reinforcement is adequate.

In my opinion the question of the use of reinforced concrete sleepers does not depend for its solution on calculations for reinforcement; the real question is the connexion between the screwspike and the reinforced concrete. We have tried metal sleeves, and these appear to be satisfactory but in my opinion the more elastic wooden attachment is preferable. If it is possible to find a wooden attachment which can suitably be connected to the reinforced concrete, the technical side of the problem will be nearing solution. The economic side of the question would, however, still remain as it is evident that reinforced concrete sleepers will be more costly than these of wood.

Mr. Desprets. (In French.) — I wish to remark that trials of reinforced concrete sleepers have been made in Switzerland and that it has been necessary to remove the packing from under the middle of the length in order to avoid breakage. This therefore confirms that they do actually bear in the centre.

Mr. Quinquet. (In French.) — The sleepers used on my system consist of blocks of reinforced concrete connected by stays; they were laid, in the first instance, on lines carrying slow traffic, but subsequently they were laid on two sections of line carrying express traffic; each of the sections is 547 yards in length, the one being on the straight and the other on curves.

One of these sections is on the Paris-Lyons line and carries trains running at speeds of 68 to 71 miles per hour; the other section is on a line on which the speed of the trains is about 44 miles per hour.

On the first trial section the ballast is of broken stones and on the other it is of fine sand. The sleepers were laid with all proper precautions and under the supervision of the makers. Care was taken to remove the ballast from under the middle of the stay in order to prevent the ends from becoming cantilevers.

As a result however of the vibration caused by the running of the trains the ballast ultimately became packed under the sleepers and the centre of the sleeper did take a bearing. Some of the stays were of reinforced concrete; of these some had broken at the centre; others were made with rolled-joists encased at their ends in the reinforced concrete blocks; in a fairly large number of cases these blocks had cracked at the point of entrance of the rolled sections. A considerable number of sleepers had to be taken up on the first section, the ballast of which, as I have stated, is composed of broken stones. Out of 676 sleepers, 373 had for various reasons to be taken out after a year of work. Those sleepers that were laid in sand ballast appear to

stand better. It is clear that sleepers of reinforced concrete can only give good results if the method of attachment is suitable. Up to this date the methods of attachment leave room for considerable improvement.

The President. (In French.) — I desire to call upon our French Colleagues for particulars relating to under bridges of reinforced concrete.

Mr. Cambournac, French Northern Railway. (In French.) — We have constructed six under bridges in reinforced concrete on lines carrying express traffic; they are arched bridges of 39 ft. 4 in. to 59 feet span and have stood very well so far as the question of strength is concerned; these arches are so constructed that there is 1 ft. 10 13/16 in. between the soffit at the crown and the rail level.

We also constructed, over the Belgian Sambre, a large span bridge of 207 feet carrying a double track. This bridge consists of two independent structures one carrying each track; the arches are hinged at the springings with a rise of 1/9.

The removal of the centering from these arches was effected by the method invented by the French engineer Freyssinet.

By this method, instead of dropping the centering from the arches the latter are lifted above the centering by separating the two half-spans from each other at the keystone, by means of hydraulic jacks acting horizontally and capable of exercising a greater force than the pressure which would have existed between the half-spans on the removal of the centering in the ordinary way.

A slab 1 5/8 to 2 inches made of rich mortar reinforced with a double netting of close mesh, is inserted into the joint that has thus been opened. These slabs, carefully measured, are of uniform thickness and are covered on each face with a fresh coating of pure cement paste 1/8 inch thick just before they are put into place. The water is then allowed to exhaust slowly from the jacks; the joint that has been open closes together on the cement slabs; the jacks are then taken out and the filling of the spaces they have occupied is effected.

The President. (In French.) — Was this work actually constructed in reinforced concrete?

Mr. Cambournac. (In French.) — It was entirely.

The President. (In French.) — I believe that this opening of 207 feet exceeds the span of any other reinforced concrete-under-bridge on main lines of railways; the future behaviour of this bridge will certainly be watched with interest by all and this will be the more easy to effect because it is situated in our own country.

Has the French Northern Railway made trials of concrete sleepers?

Mr. Cambournac. (In French.) — We have confined ourselves to following the trials made by other railway systems. In common with other railway companies we think that so far they are not really satisfactory.

The President. (In French.) — I think that we may consider the discussion on reinforced concrete sleepers as closed.

Another question has been raised in one of the reports relating to the flaking of reinforced concrete in over bridges due to the locomotive traffic and the action of the smoke.

Mr. Duplaix, French State Railway. (In French.) — In two cases we found that the locomotive smoke had attacked the reinforcement of concrete structures

spanning the tracks, and had produced cracks that had caused the concrete to flake away : the flooring of a bridge beneath which locomotives frequently stop and also parts of a pier had been attacked in this way.

This is indisputable proof that reinforced concrete structures can be damaged by the action of smoke; it is possible that it is due to want of thickness in the concrete between the reinforcement and the outer surface, and it will perhaps be necessary in the case of work exposed to smoke, to increase the thickness of the concrete so as better to protect the steel reinforcement.

Mr. Mesnager. (In French.) — We have made a small scale model, 1/5th full size in the laboratory of the Roads and Bridges Department, on the request of Mr. Rabut with a view to practically testing a structure that he proposes to build.

There are only a few millimetres of mortar between the reinforcement and the outer surface. We have found that in time this model is attacked by atmospheric agency.

I think that it is absolutely essential that, in reinforced concrete structures, there be 1 inch thickness of cement between the reinforced bars and the outer surface, otherwise we shall be liable to the troubles that have been mentioned by Mr. Duplaix.

In France there is a bridge of about 558 feet in length constructed of reinforced concrete. When this structure was built account had not been taken of the expansion of reinforced concrete under the influence of heat. As the result of cold, cracks 5/32 to 3/16 inch in width opened. The reinforcing bars exposed to the air become oxidized and the rust spread under the concrete which fell in lumps the size of one's hand. This bridge has since been repaired. This fact shows the danger that exists when the reinforcements are inadequately protected by mortar.

Mr. Dreyfuss, French State Railway. (In French.) — The French State line (formerly the French Western Railway), has had reason to note numerous cases in which the cement and the concrete of road-bridges have been attacked by the smoke of locomotives. The following are two cases in point :

In a tunnel at the Passy station on the Auteuil line, on which there is very heavy traffic, the trains following each other about every five minutes, it was decided to strengthen the girders at the mouth of this tunnel by means of reinforced concrete, it being thought that this would protect the steel part of the structure which had been considerably attacked, and at the same time strengthen the structure as a whole. This however was far from proving to be the case.

This structure is situated at the departure end of the platform at the commencement of a gradient so that there is a two-fold reason for the locomotives making a special tractive effort at this point; the exhaust steam and smoke have attacked the concrete, which, after a year, has become pasty and disintegrated owing to the action of sulphates contained in the smoke.

This is not the only example; we have a lengthy experience which has shown that it is necessary to protect reinforced concrete effectively against locomotive smoke.

The other case is that of the Cardinet bridge at the end of the Batignolles cutting. This bridge is not built of reinforced concrete, but is a metal bridge encased in concrete. Less than two years after it had been constructed we found

that the concrete had been attacked and the metal laid bare, so that we were forced to repair the cracks and to take measures for its protection against attack.

The President. (In French.) — Does the coal you use contain much sulphur?

Mr. Dreyfuss. (In French.) — There is not a great deal; the smoke is never yellow in colour [1].

We thought that « ciment fondu » might give better protection and we are studying the question by local tests, particularly in a tunnel in which we are examining the action of smoke on cement mortar.

In the case of a tunnel under repair on the line from Mantes to Caen; all the exposed portions of the mortar have been attacked by locomotive smoke; we have applied « ciment fondu » and have, so far, obtained good results.

Wherever we have used « ciment fondu » on the French State Railway system, which, as you are aware, comprises a number of suburban lines, carrying heavy traffic, it has proved the solution of a number of difficulties.

Mr. Mesnager. (In French.) — It is known that on lines carrying heavy traffic the arches of underground tunnels are attacked by smoke; thus on the Paris Ceinture Railway it has frequently been necessary, in the tunnels, to repoint the joints in the arches, owing to their destruction at some parts of the line by the action of the locomotive smoke.

Mr. Quinquet. (In French.) — Is not this deterioration due to mechanical action? Locomotives with very violent exhaust can produce an almost continuous hammering on the arch; we have frequently found that stones become detached.

Mr. Séjourné. (In French.) — We may say that all materials without exception; cast-iron, stone and mortar as well as cement are attacked by locomotive smoke.

The President. (In French.) — Is it not possible to arrive at a definite conclusion that reinforced concrete is not immune from the attacks of smoke.

Mr. de Boulongne. (In French.) — This is the more important because the relining of tunnels is difficult to carry out under good conditions.

The President. (In French.) — One of our colleagues has something to say on the use of concrete in countries subject to earthquakes.

Mr. Gioppo, Italian State Railway. (In French.) — Amongst the applications of reinforced concrete to the construction of railway structures (workmen's houses, passenger-station buildings, goods warehouses, locomotive sheds, workshops, etc.) there is one special application, which forms a new branch of the art of the railway engineer, and one that has found widespread use in Italy (particularly in Calabria and in Sicily). I refer to structures and arrangements of special character which it has been found necessary to adopt in those districts in which earthquake shocks have caused terrible catastrophes.

Everyone in the world was deeply affected on learning the news that, in the early hours of 28 December 1908, one of the most violent earthquakes recorded in history had destroyed the two towns of Messina and Reggio, as well as a large number of small villages, involving the death of 150 000 people. At Messina

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[1] The amount likely to occur in any coal would not give this colour. (*English Editor.*)

alone which then had a population of 110 000 inhabitants there were 85 000 victims. More than nine-tenths of the buildings collapsed completely, whereas the remainder were all more or less damaged.

The technical side of the art of construction was thus brought into operation to solve a problem of the greatest importance. This problem could be regarded from two points of view: on the one hand, it was necessary to devise methods of construction proof against earthquakes, and on the other to determine the horizontal and vertical forces which might be produced by the strongest shocks, either vertically upwards or undulatory, to enable formulæ to be arrived at for calculating the requisite strength of the structures.

It is therefore a problem in construction that involves applied mechanics at the same time.

Since 1783, shortly after the destruction by an earthquake of a very large number of towns, the old Government of the Bourbons published some well considered provisions relating to the permissible number of storeys, the securing of joists to the walls by chains and the form of construction of the roof with a view to reducing the thrust of the trusses against the walls.

But these rules soon fell into disuse. It is quite true that the constructional materials that are in use at the present time were not then known, nor the present technical methods, which are incomparably better, as shown by the reinforced concrete structures of the present day.

There is moreover no conception of the magnitude of the forces exerted by earthquake shocks.

The study of these forces, which up to quite recent times has been entirely left to geologists, has now come also within the province of engineering art.

Professor Omori of Tokio University is specially well known for research work of this kind, as is Professor Oddone of the geodynamic Observatory at Rome and particularly Father Gui Alfani of the Ximinian Observatory at Florence. The primary object was to estimate the external forces which the structures would be required to withstand, by calculations based on shock diagrams, as recorded on the seismographs, due account being taken of the imperfection of the instrument in its effect on the drawing of the seismic diagram.

Thus the maximum accelerations were obtained by calculation, which, applied to the masses of the constructional work in the buildings, gave at once the external forces and enabled data to be obtained for future use in calculation.

It was, however, necessary for practical technology to draw up rough rules for readily estimating the actual forces.

For this purpose the Italian Government appointed a Commission composed of men of eminence in the scientific and technical world. This Commission was entrusted with the investigation and framing of compulsory regulations affecting repairs, reconstructional work and new structures to be executed in the seismic regions.

On 8 April 1909 this Commission handed in its recommendations on which the compulsory regulations were based; these, with some modifications which have since been introduced constitute the Act, No. 1399, passed on 19 August 1917.

According to these regulations buildings may not exceed a height of 32 ft. 10 in. on flat ground, and 36 ft. 1 in. on sloping ground, provided that the mean height in no case exceeds 32 ft. 10 in. No building is to exceed two storeys in height. Arched structures above the

ground and also roofs exerting lateral thrust are prohibited. The portion of the buildings that carries the weight (the framing) is required to be of sufficient strength to withstand the ordinary loads, increased by those which may arise in consequence of the vertical and horizontal forces consequent on seismic action.

The forces due to undulatory shocks are reduced to forces acting horizontally applied at the level of the various floors and over the length of the walls, and these correspond to one-sixth of the weight of the structures on the first floor and to one-eighth of that on the ground floor; before the disastrous earthquake at Avezzano (in January 1915) these coefficients were only one-eigth and one-twelfth respectively.

In the case of forces due to vertical and upward shocks and analogous method is followed to that in use for the calculations for steel bridges : the masses set in motion being treated as having increased weight. With this object it is required that the weight be increased by 50 % for the various parts of the structure. Compensation is however introduced into the calculations by taking into account the stability of the walls of the building themselves.

It is therefore quite natural that, for such structures, reinforced concrete should offer the best solution. For this reason the Italian State Railways have made use of it for numerous structures that they have carried out in the seismic regions.

All anti-seismic structures. should, in general, consists of a gridwork foundation laid on the actual earth, if the latter has sufficient resistance, or otherwise on a suitable sub-foundation. This gridwork is formed of reinforced concrete ribs which in most cases form rectangular meshes which correspond to the outer walls and to the interior walls in both directions. Where the ribs forming the gridwork cross each other (at places that correspond to those where the walls cross), pillars of reinforced concrete are raised to the level of the gutters. At each floor level these pillars are connected to each other in every direction by other girders which form an integral part of the flooring, which is itself of reinforced concrete. The spaces in the framing between the pillars and the through girders are filled in with brickwork.

The main structure that I have just described is then completed by the secondary structure which consists of string courses, of reinforced concrete, inserted in the brickwork at the level of the window sills, and further strengthened by the framework of the doorways and of the windows and the window jambs, so that each opening is enclosed in a strong frame of reinforced concrete.

Cornices carrying the gutters are also made of reinforced concrete, as are the attics, the staircases and the balconies.

By this method a monolithic structure is obtained which is tied together in all its details, and appears to form, within the limits of human knowledge, the structure best calculated to withstand the violence of seismic shocks should they occur; and at the same time the most economical form of construction.

It is to be hoped that these buildings will not be put to the test.

The President. (In French.) — We wish to express our earnest hopes for the success of the attempts that have been made in Italy in order that that beautiful country may at last be protected against

catastrophes which, on so many occasions in its history have been accompanied by great loss of life.

I think that after two long sittings we need rest, we will adjourn the meeting until to-morrow morning.

Meeting held on 26 April 1922 (morning).

Mr. BRUNEEL, IN THE CHAIR.

Mr. Desprets, Belgian State Railway, reads (in French) the minutes of the discussion held on 25 April.

The preparation of the report in abstract is approved.

The President. (In French.) — I will ask Mr. Golard to read the summary which he has prepared in conjunction with Messrs. Bülow and Leemans regarding question IV.

Mr. Golard, *reporter*. (In French.) — Mr. Grierson has made an accurate summary of the reports sent in by the reporters. Nevertheless neither Mr. Bülow, Mr. Leemans nor myself can agree with his conclusions which are too severe respecting railway under bridges.

We therefore propose that the following resolutions, which have moreover the support of Messrs. Cambournac and Boulongne, be adopted. Article 5 relating to applications of « ciment fondu » has been prepared by Mr. Mesnager.

Summary.

« 1° The use of ordinary concrete and reinforced concrete has found a most extended field of applications in all classes of railway structures. For many works according to local conditions, these materials are often more economical than masonry or steel. Works of this class include particularly bridges, foot bridges, buildings, workshops, locomotive sheds, goods warehouses, and overhung or veranda roofs for passenger and goods platforms;

« 2° In the design of a reinforced concrete structure due care must be taken of:

« *A*) the characteristic properties of reinforced concrete especially bearing in mind the temperature and the contraction of concrete during setting;

« *B*) the methods adopted in carrying out the work on the site.

« The drawings should be carefully prepared, particularly the details of the joints of the bars, which should be shown in such manner as readily to make clear what is intended. Works in reinforced concrete require constant supervision by competent technical men on the site, who have had the necessary practical experience. Special care should be taken in the choice of suitable materials, and close supervision should be exercised to see that the dimensions and positions of the bars are correct, and that too much moisture was not used. The concrete should be well rammed at every stage of its construction;

« 3° When properly designed, with suitable materials, the cost of maintenance of works in concrete and reinforced concrete should be about equal to that of similar works constructed in stone or in

brickwork; the cost of maintenance is considerably less than that of steel work;

« 4° For railway bridges which are subject to dynamic forces there appears to be no technical reason against the use of reinforced concrete which is of general advantage, but requires very close supervision in its execution. It is always advantageous to lay a bed of ballast, or an elastic layer of wood, between the track and the concrete, and it is necessary that the surface of the concrete should be maintained in a thoroughly watertight condition;

« 5° It would be interesting to follow the result of the use of « ciment fondu » which appears of distinct value in several classes of work and which appears to offer exceptional resistance to the deleterious effect of water containing sulphates and sea water;

« 6° It is desirable that the results of trials which are being carried out by various Administrations of the use of reinforced-concrete sleepers should be recorded; these latter will form a valuable adjunct to the supply of wooden sleepers and, in that event, an efficient check upon their cost. »

Mr. Barrand, *vice-president.* (In French.) — I think that it would be necessary to add some few words to the effect that in works exposed to locomotive smoke it is necessary to provide a sufficiently thick coating of concrete between the metal and the exterior in order to preserve the steel.

The President. (In French.) — Is this not a requirement under the general regulations in force in France?

Mr. Barrand. — Yes, but I suggest that a reference in the summary would be useful in as much as the French are not the only people making structures of reinforced concrete.

The President. (In French.) — The Office will find a satisfactory wording.

Mr. Barrand. (In French.) — In the list of works, for the construction of which reinforced concrete has been used it would be well to add « water towers ». A great saving was possible in works of this kind.

Mr. de Boulongne. (In French.) — During the war we had to build two reservoirs each of 176 600 cubic feet contents in a very short time, as they were most urgently required. It took two and a half months to prepare the designs and construct them in concrete. These reservoirs are 98 ft. 5 in. in diameter and 23 feet in height.

The President. (In French.) — Are they raised reservoirs or built on the ground?

Mr. de Boulongne. (In French.) — They are built on the ground. The round form was arrived at after careful study of the question.

The President. (In French.) — This would further add to the recognition of the value of reinforced concrete and happily complete the remarks I made yesterday.

The words « water towers » will be added in the text.

I would myself suggest some modifications in the wording.

The second sentence in article 1° contained : « according to local conditions » which would appear to imply an alternative; now there was no alternative. It would therefore be better to say : « the prices of work executed with these materials... »

Under 2° instead of the word « temperature » it would be better to read : « coefficient of expansion ».

Mr. Desprets. (In French.) — In official

documents the term « effects of temperature » is used.

The President. (In French.) — Such being the case, then let us also say : « effects of temperature ».

Mr. de Boulongne. — I agree that this wording is more correct.

The President. (In French.) — Under 3° we should read : « the cost of maintenance of works in concrete, or in reinforced concrete » instead of « and in reinforced concrete ».

Under 4° the words of « general advantage » rather exceed what was said and I propose to say : « can frequently be used advantageously ».

Mr. de Boulongne. (In French.) — This is my opinion.

Mr. Séjourné. (In French.) — Economy effected by the use of concrete depends on circumstances.

The President. (In French.) — The word « frequently » is therefore correct.

Under 5° it would be well, in my opinion, to substitute for the word « appear » the words « should prove » and to say : « It would be interesting to follow the result of the use of « ciment fondu » which should prove... »

Mr. Séjourné. (In French.) — « Ciment fondu » is of value, not only in the composition of concrete, but also mortar when used in brickwork or masonry.

Mr. de Boulongne. (In French.) — The conclusion relates to reinforced concrete only.

The President. (In French.) — We must not prejudge the future.

Mr. de Boulongne. (In French.) — There are two methods of preparing « ciment fondu » : by means of the ordinary furnace and by means of the electric furnace. We are still in the trial period.

Mr. Mesnager. (In French.) — I think that it would be preferable to state « might for various works ».

The President. (In French.) — I suggest that we should delete the words : « for the applications of reinforced concrete » we should thus increase the scope.

Mr. de Boulongne. (In French.) — It would be necessary to correct the end of the phrase and to say : « which should prove of distinct value in several classes of work and which appears (for in this case « which appears » is necessary) to offer exceptional resistance, etc... » (*Approval.*)

The President. (In French.) — I finally propose a slight modification in article 6°. Instead of saying « These latter will form an adjunct » it would be better to use the conditional « might form ».

Mr. Grierson, *special reporter.* — I am afraid I cannot agree with the conclusion expressed in 4° that there is no objection to the use of reinforced concrete for underbridges submitted to dynamic stresses. This is not in accord with the general views expressed in the various papers, and, certainly, actual experience has not yet demonstrated that such is the case. The conclusion appears to go rather further than is justified.

Mr. de Boulongne. (In French.) — It is difficult to make further modification without saying the contrary.

To state that « nothing would appear to prevent », did not necessarily mean that it was so.

Mr. Barrand. (In French.) — The examples quoted are rather in its favour.

The President. (In French.) — I think the only doubt that can arise relates to the extreme limits of span. Our English colleagues are satisfied with the correction « appears ».

Mr. Grierson. — I am in agreement if you insert « do not appear to exist against the use ».

Mr. Barrand. (In French.) — It is a question of form.

The President. (In French.) — The amendment suggested by Mr. Grierson is really not quite accurate. If no one has any further remarks I declare the summary adopted with the modifications that have been agreed.

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The President (In French), then makes the following address :

Gentlemen,

We have now arrived at the end of our work in this section. It is not without emotion that, remembering as I do the time we have spent so cordially together, building up mutual esteem and confidence in one another, I think of our coming separation. Less than anyone else am I likely to forget the very pleasant time we have passed together, for, as I said in my inaugural address, I consider the honour you have conferred upon me as the crowning success of my career, and I sincerely trust that the friendships which have been established here may be maintained, and it will afford no one present greater happiness than myself if happily these friendships are maintained.

We may, I think, all of us congratulate ourselves on the results at which we have arrived. It may be that this meeting of ours, which has enabled us to work together usefully and harmoniously in the interests of progress, may have done more than some other conferences which have been held — conferences called together with great solemnity, and of which the echoes ring throughout the world — for furthering the welfare of the whole of humanity.

The friendships which have sprung up here between the very able delegates of different nations throughout the world involve a solidarity that will not end with the close of the present session of the Congress.

The very pleasant task remains for me to propose that our sincere thanks be given to the Vice-Presidents, Messrs. Barrand and Deyl, who have so ably helped and supported me in the very heavy task that you entrusted to me. My thanks and gratitude are also due to the Principal Secretary, Mr. Tronconi, and to the Secretaries who have shown such untiring zeal, not only during our sittings, but also during those hours that we devoted to our recreation. (*Applause.*)

These sincere thanks, Gentlemen, give me much pleasure on ceasing the occupancy of the chair with which you have honoured me. (*Applause.*)

Mr. Barrand. (In French.) — Gentlemen, I am sure I shall be expressing the views of all of you when I tell our President how grateful we are to him for the able, fair and courteous manner in which he has presided over our discussions; by his tact he has always been able to get agreement upon resolutions in regard to which differences originally existed.

On behalf of you all I desire to convey to him our heartiest thanks and our sincere good wishes for the future. (*Applause.*)

The President. (In French.) — I need not tell you, Gentlemen, with what emotion I have listened to the kind remarks of Mr. Barrand. My special thanks are due to you, Gentlemen, for the manner in which you have received them and I thank all of you most heartily, my colleagues or rather, may I say, my friends. (*Applause.*)

Mr. Grierson. — On behalf of my British colleagues and myself, I would like to express our appreciation of the very able and courteous manner in which the President has conducted the discussion. The results, especially in the form of the printed records, should prove of great value. The difficulty of conducting a debate in several languages is considerable, and I am glad to have the opportunity of acknowledging our indebtedness to the interpreters for their great assistance.

We all very much appreciate the cordiality with which we have been received, and the courtesy extended by the delegates present throughout the course of our work, and we look forward to the pleasure of meeting them again at the next Congress. (*Applause.*)

DISCUSSION AT THE GENERAL MEETING

Meeting held on 28 April 1922 (**morning**).

Mr. R. DE CORNÉ, HONORARY VICE-PRESIDENT, IN THE CHAIR.

GENERAL SECRETARIES : Mr. J. VERDEYEN; Mr. E. FRANZA; Sir HENRY FOWLER.

ASSISTANT GENERAL SECRETARY : Mr. N. GIOVENE.

Sir Henry Fowler, *general secretary*, read the

Report of the 1st section.

(See *Daily Journal of the session*, No. 9, p. 6.)

« At the invitation of the PRESIDENT, Mr. GRIERSON read his special report followed by a short summary. The points he developed in his own report were those relating to Great Britain. He laid special emphasis on the fact that one ought to be extremely careful in the construction of reinforced concrete as it was often found that the results of laboratory experiments were carried out under different conditions to those which pertained on the work itself. He also expressed doubt as to the durability of concrete work, and he thought that the effect of dynamic loads (*impact*) on reinforced concrete constructions was not thoroughly understood.

« Mr. MESNAGER (*French Government*) did not agree with the doubts which Mr. Grierson had thrown upon direct tests, which ought to be reliable if carried out in the shops, or even on the works, as under these conditions the experiments ought to be sufficiently trustworthy to give confidence in the results.

« On the other hand he would also point out that the remains of the Roman buildings in concrete is a guarantee of durability of erections in reinforced concrete.

« With regard to the question of impact, the official regulations keep this sufficiently in mind, and he did not know of a failure of reinforced concrete when the calculations had been properly carried out in accordance with the regulations mentioned.

« THE PRESIDENT asked Mr. Séjourné to speak on the question of the use of « Ciment fondu » (melted ciment) in tunnels.

« Mr. SÉJOURNÉ (*Algerian section of the Paris, Lyons and Mediterranean Railway*) spoke of the experience on a tunnel of the Nice-Coni line where « Ciment fondu » alone had resisted the action of the water containing sulphates, all other cements having given bad results.

« The actual experience with this material has now extended over five or six years, which should be sufficiently conclusive.

« Mr. MESNAGER at the invitation of the President gave a short description of the

characteristic properties of « Ciment fondu ». This material, which has a composition high in aluminates, acquires in about three days a strength equal to that which ordinary slow cement reaches in six weeks; it continues to harden in this manner which gives it two important advantages :

« 1° The possibility of removing the « shuttering » after a very short time;

« 2° The possibility of reducing (to about a half) the dimensions of the concrete members.

« This cement costs double that of ordinary cement, but nevertheless gives a very considerable economy resulting partly in the carrying out of work with a limited quantity of « shuttering ».

« Mr. Bülow (*reporter*) gave a resume of his report, and called particular attention to the necessity of proceeding with a careful mixing of the concrete.

« The President spoke very highly of the new material which had allowed them in Belgium to reconstruct in a specially rapid manner the works destroyed during the retreat of the conquered armies.

« Having regard to the very large amount of ground which they had to cover, he proposed to limit the discussion to the several special applications of reinforced concrete. He particularly desired to call attention to the importance on the care necessary in carrying out works in reinforced concrete. He thought they should also spend some time on the question of under bridges, the influence of electric traction on work in reinforced concrete and on reinforced concrete sleepers. He pointed out in addition what might be called a secondary use of the material, such as the Belgian State Railways had put it to the manufacture of signal posts since the armistice.

« Mr. Deyl (*Czecho-Slovakia State Railway*) spoke of very interesting work which had been carried out entailing a reinforced concrete arch having a span of 55 ft. 9 in. built at Pilsen by the Melan system, and of a railway bridge directly under the main roads, having an opening of 29 ft. 6 in. These constructions had given every satisfaction.

« Mr. de Boulongne (*Paris, Lyons & Mediterranean Railway*) said that in his opinion cements with high silicon contents have mechanical properties comparable with those of « Ciment fondu », they retained in setting the properties of cements which set slowly. In the long run strength attained by this means are equivalent to those of « Ciment fondu ». He desired also to call the attention of this section to the necessity of taking every care in carrying out work in reinforced concrete, the defects which occur chiefly point to the use of too wet a mixture. He concluded by saying that he had every confidence in such works carried out under satisfactory conditions.

« Mr. Lolli (*Italian State Railway*) stated that the Italian State Railway had constructed since 1900 more than 500 bridges in reinforced concrete, with straight girders. These are from 39 ft. 4 in. to 46 feet span, and are standing well up to the present. The cracks which have shown are solely due to the shrinkage of the cement, and not to the effect of the rolling load. The trials carried out in 1918 showed that these constructions had not suffered any diminution of strength. Dealing with the question put by Mr. Séjourné, Mr. Lolli stated that no oxidisation of the rods had occured due to these cracks.

« Mr. Bauër (*French State Railway*) wished to inform the Congress that the

results obtained by the French State Railways on bridges of reduced span over which trains run at high speeds had been satisfactory.

« Mr. Quinquet (*Paris, Lyons & Mediterranean Railway*) made an interesting contribution to the discussion relative to the strengthening of certain cast iron work by means of reinforced concrete. The method employed consisted in placing round bars along the members in tensile stress and embedding them in concrete, this allowed of very considerable economy in the expense of strengthening the structure.

« Mr. Bülow also gave a résumé of part of his report relating to under bridges.

« Mr. Tintant (*Eastern Railway of France*) spoke of a bridge reaching a length of 82 feet constructed for the lines of a light railway.

« The President mentioned the question of the effect of electric traction on under bridges. Exact information was not yet available on this point.

« He then raised the discussion on the question of reinforced concrete sleepers.

« Mr. Barbieri (*Italian State Railway*) gave an account of the trials on these made on the Italian State Railway. A summary of these had been published in the report of Mr. Golard, all that could be said at present was that the problem they presented was not solved.

« The President said that he judged that in countries where trials of them had been made on a large scale the experiments had not been conclusive.

« Mr. Balling (*Paris-Orleans Railway*) spoke of the trials being carried out by his company.

« Mr. Desprets (Belgium) described the various methods which are employed in the manufacture of reinforced concrete sleepers. On the one hand the sleepers are shaped very similar to the wooden ones, whilst the other type consists of blocks under each rail joined together (type tried by the P.-L.-M.). It is remarkable to note that the sleepers last tried on the Italian State Railway and on the Paris-Orleans line are of the same length (7 ft. 10 1/2 in.), which is that of equal stress so as the length of 8 ft. 6 3/8 in. for a wooden sleeper is that of equal deformation. It is yet doubtful if the reinforcement used is sufficient. In this respect the sleepers consisting of two blocks rigidly united (P.-L.-M. type) ought to be better able to solve the question.

« Mr. Balling thought that the attachment of the rail was a delicate matter with the material under discussion and that an ideal method of attachment had not yet been found.

« Mr. Quinquet said that with sleepers consisting of *blocks* with a joining piece of reinforced concrete, most of the joining pieces broke in the middle.

« Mr. Cambournac (*Northern Railway of France*) stated that they had recently constructed several bridge girders of this material on the Northern Railway, one of these for an arched bridge on the Belgian Sambre was 207 feet long. Up to the present the results had been satisfactory.

« The Northern Company had followed, with interest, the experiments which other companies were making with reinforced concrete sleepers, but he did not believe they would at present employ them on his railway.

« Mr. Duplaix and Mr. Dreyfuss (*French State Railway*) called attention to

the destructive effects of the smoke from locomotives on reinforced concrete.

« Mr. MESNAGER pointed out that it was necessary to have a certain thickness of coating around the rods in order to preserve them from the effect of corrosive smoke. He also called attention to the fact that the lower footings of the masonry in tunnels are sometimes attacked by water containing sulphuric acid derived from the smoke.

« Mr. GIOPPO (*Italian State Railway*) gave an interesting account of the method of calculation employed for reinforced concrete structures to be erected in countries which were liable to earthquake shocks.

« THE PRESIDENT asked Mr. DESPRETS to read the reports of the meeting on the use of ordinary cement and of reinforced concrete on railways. This was adopted without discussion. Mr. GOLARD (*reporter*) then read a summary of the discussion on the various points. He appreciated very fully the report made by Mr. Grierson, but thought that the conclusions he drew up ought to be enlarged as concerned under bridges. After a short interchange of views, in which the President took an active part, the section agreed on the following. »

The President. — This is the

Final summary.

« 1° The use of ordinary concrete and « reinforced-concrete has found a most « extended field of applications in all « classes of railway structures. The prices « of work executed with these mater- « ials are often more economical than ma- « sonry or steel. Works of this class in- « clude particularly bridges, footbridges, « buildings, workshops, locomotive sheds, « goods warehouses, overhung or veranda « roofs for passenger and goods plat- « forms, water towers, etc.

« 2° In the design of a reinforced con- « crete structure, due care must be taken « of :

« *a*) the characteristic properties of « the material, especially bearing in mind « the effects of temperature and the con- « traction of concrete during the set- « ting;

« *b*) the methods adopted in carrying « out the work on the site;

« The drawings should be carefully « prepared, particularly the details of the « joints of the bars, which should be « shown in such a manner as to readily « make clear what is intended. Works « in reinforced concrete require constant « supervision by competent technical men « on the site who have had the necessary « practical experience. Special care « should be taken in the choice of « suitable materials, and close supervi- « sion should be exercised to see that the « dimensions and positions of the bars « are correct, and that too much moisture « is not employed. The concrete should « be well rammed at every stage of its « construction;

« 3° When properly designed, with « suitable materials, the cost of main- « tenance of works in concrete or rein- « forced concrete is sometimes almost « negligeable; more often than not it is « less than that of masonry or brickwork, « and considerably less than that of steel- « work;

« 4° For railway bridges, which are « subject to dynamic forces, there appears « to be no technical reason against the « use of reinforced concrete, which can « frequently be used advantageously,

« but requires very close supervision in « its execution. It is always advantageous « to lay a bed of ballast or an elastic « layer of wood between the track and « the concrete, and it is necessary that « the surface of the superstructure « should be maintained in a thoroughly « watertight condition;

« 5° It would be interesting to follow « the result of the use of « Ciment fon- « du », which should prove of distinct « value in several classes of work and « which appears to offer exceptional « resistance to the deleterious effect of « salt water consequent on the presence « of sulphate of magnesia;

« 6° It is desirable that the results of « trials which are being carried out by « various administrations of the use of « reinforced concrete sleepers should be « recorded.

« The latter might form a valuable ad- « junct to the supply of wooden sleepers « and in that event form an efficient « check upon their cost. »

— The general meeting ratified this summary.

[624 .63 & 721 .9]

APPENDIX.

Note on the use of ordinary concrete and reinforced concrete in the construction of the Czecho-Slovakian Railways,

By I. KOVAŘÍK,
ENGINEER.

It is only during the last ten years that concrete has found many uses in all branches of railway constructional work. If use was not made earlier of concrete it was due to the fact that there was abundance of good and cheap building stone, and that the price of masonry was not appreciably greater than the cost of concrete.

The more frequent use of concrete commenced with the adoption of reinforced concrete for constructional work.

Ordinary concrete is used at the present time for the foundations of important structures and particularly for those involved in the doubling of the track of the Bratislava-Břeclava line which was carried out in 1920-1921. As examples of ordinary foundations of great depth we may mention those of the bridge over Doudlevecká Street in Plzeň, 52 ft. 6 in. deep; electric elevators were used for the removal of spoil and for lowering the concrete on the site. Foundations below water level have required the use of caissons either of reinforced concrete, as in the case of the bridge built in 1920 over the Bečva near Přerov, or of wood as used for the bridge over the Morava near Břeclava built in 1921. The depth of the foundations was in both of these instances about 32 ft. 10 in. below the water level. The piers were of ordinary concrete and cased with a facing of dressed ashlar.

In the case of a foundation on ground that will not carry a heavy load, and for foundations on embankments, successful results are obtained by the use of a system of inverts having a thickness of from 2 feet to 3 ft. 3 in. reinforced with round steel-bar (as used in the foundation-bed for the new building constructed for the Administration at Karlin), or of old rails (as in the under-bridge at Česká Lipa). Both of these works were executed in 1921.

The inverts for the bridge constructed in 1921, at km. 7.7/8 on the Břeclava-Kúty line for widening it to double line, were carried on wooden piles, as the subsoil was a quicksand.

The tops of culverts not exceeding 6 ft. 6 3/4 in. are made of sections consisting of rails encased in concrete; for culverts having a span of up to 29 ft. 6 in. steel joist is used with concrete casing, or riveted girders are used in place of joist, the concrete being mixed in the proportion of 1 to 5. Up to the present the only arch bridge built with concrete is one of 55 ft. 9 in. span over Doudlevecká Street in Plzeň, which was constructed on Professor Melan's system. The arch is elliptic and skew carrying four main lines of track. Up to the present time no slabs or arches with round steel-bar reinforcement have been constructed on main lines; the only structure built with a floor on the Hennebique system was constructed in 1921 on the private branch line running to the explosive works at Rosice near Pardubice. In the same year some over foot-bridges of the bow-

string type were built over the Lysá-Děčin line with round steel-bar reinforcement.

The lining of the tunnel at km. 24.4/6 on the Eisenstein-Plzeň line, constructed between 1912 and 1914, is also of reinforced concrete; for this purpose rigid arch-shaped reinforcement made of old rails was used; these were bent hot with the sole towards the inside of the tunnel. The reinforcing rails were spaced 3 ft. 3 3/8 in. from each other and connected to one another by tie-rods. The bent rails rest at their base on an iron plate. As it was necessary to prevent the infiltration of water and the decomposition of the soft gneiss by contact with the air, the thickness of the concrete required was as much as 11 3/4 inches. The water used was mixed with 2 per cent of soft (potash) soap; the upper part of the arch was faced with fine concrete and the water was led away by drain pipes to the main drains.

The floors of metal bridges, for spans of from 3 ft. 3 in. to 65 ft. 7 in. are also made of concrete. These floors require to be reinforced and made of the best quality concrete, the usual mixture being 1 to 3. For the construction of the bridge over the Radbuza at Plzeň (1914) the two piers were enlarged by the addition of concrete work connected to the old masonry structure and reinforced in the vertical direction by old rails. In this case also the bearing surface above the masonry was enlarged by means of brackets or corbels of reinforced concrete.

With reference to the construction of buildings, the use of reinforced concrete has not yet been extended to the same extent as in other countries, the use of concrete being limited usually to the ceilings of dwelling houses and of workshops. The reinforcement used is round steel-bar. Moreover, during the last few years a number of signal cabins and huts have been constructed of cinder concrete.

Up to the present time reinforced concrete sleepers have not been used, and it would appear that, owing to their great weight and fragile nature, the use of reinforced concrete sleepers will not take place for a long time, particularly as the State produces an excess of good wooden sleepers. Trials made, on a small scale, with cinder-concrete sleepers at Olomouc have not given good results.

On the other hand concrete culverts have been successfully used for rope transmissions, reinforced concrete poles have been used for carrying electric supply wires, and concrete has been used for the foundation blocks for signals and for carrying transmission details.

Up to the present time only limited use of reinforced concrete has been made in the construction of retaining walls. The side-walks on bridges are most frequently made of slabs reinforced by round steel-bar.

No reinforced concrete piles have been used up to date.

Works of concrete or reinforced concrete have not been in existence for a sufficiently long time to allow of a definite opinion being given on their durability; some of their advantages, however, cannot be overlooked. In the first place, it must be noted that concrete work costs little for maintenance, that it can be constructed both cheaply and easily and the concrete can be used for work of different classes. One difficulty that arises in the construction of reinforced concrete work is that due to the necessity for making complex and costly shuttering as well as scaffolding; concrete moreover sets slowly; structural works in concrete require continuous inspection and offer difficulties in repairing.

For the construction of main-line railway bridges, up to 29 ft. 6 in. span, cross girders have been made of encased rolled joist. This form has, so far, given excellent results.

With regard to the influence of smoke,

fire and electric currents owing to the short time that has elapsed since the structures were made, it is impossible to make any definite statement.

As the quality of concrete depends on the methods and care used in the work and in the manufacture of the concrete, structures should be built under constant and efficient supervision. At the same time it is necessary to see that the mixing of the concrete is carried out to suit the shuttering in place and to ensure that the shuttering should not be removed too soon. The amount of water added has a great influence on the strength of the concrete. The concrete after being put into place should not be subjected to rapid drying, moreover, particularly in summer, it should be protected from the direct rays of the sun. When it has been necessary to use concrete somewhat dry, care should be taken to keep it wetted by spraying for some time in order to allow of its setting in a proper manner.

The tests of concrete are made on test cubes measuring 7 7/8 inches each side.

In constructional work with rigid reinforcement, the shuttering boards are hung under the reinforcement in order to save the cost of expensive scaffolding (as in the Melan system using encased rolled joist).

The time that should elapse before removing the shuttering is determined by the regulations in force. There are also regulations relating to the testing of the cement and the concrete. As the cement made in the country is of excellent quality a crushing strength has frequently been obtained with the concrete of over 4 267 lb. per square inch. The maximum permissible stress allowed is 853 lb. per square inch. In order to obtain impermeability in the concrete 2 % of soft (potash) soap is added to the water; moreover it is also usual to cover the concrete structure with cement coat to a thickness of 1 3/16 to 1 5/8 inches. This covering is equalized over the upper part and covered with a double coat of asphalt mixed with tar; sacking is placed between the two water-proof layers.

In the case of under-bridges, if the thickness of the ballast is small, it is advisable to protect the coating by means of a layer of covering reinforced with strong wire netting in order to prevent it from being damaged when the sleepers are being packed.

In order to improve the appearance of concrete structures, colouring matter or small stones are sometimes added on the outer face of the concrete of the structure. After removal of the shuttering the facings can be axed or fine-axed, so as to produce the effect of a building in hewn masonry.

From this summary relating to the use of concrete and reinforced concrete, an idea may be obtained of the importance which concrete has assumed as a constructional material during the last few years. It is, however, necessary to draw attention to the care that must be taken in the preparation of ordinary concrete and also of reinforced concrete, and further to the need of the necessary experience in using this material.